Food Material Science 2011/12
Inneke Hantoro

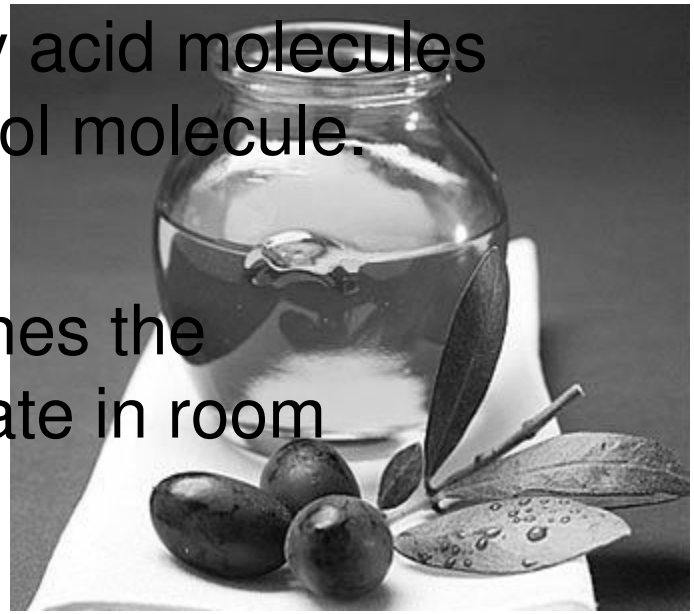
Definition & Composition of Fats

- Fats: simple lipids, compound lipids, composite lipids, spingolipids, derived lipids.

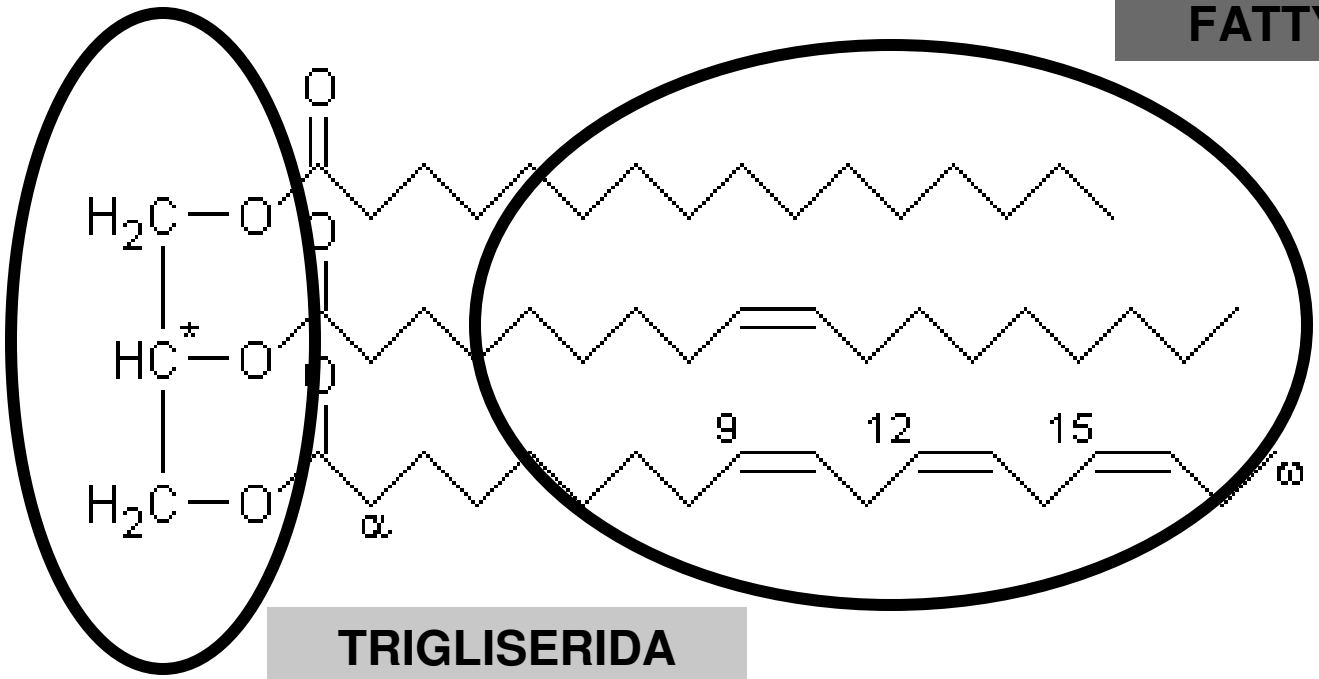
- Simple lipids --- triglycerides (the major components of fat, butter, shortening & oil).

- A triglyceride molecule of fat: 3 fatty acid molecules connected to (or esterified) a glycerol molecule.

- The structure of fatty acids determines the properties of fats (ex. solid/liquid state in room temperature).

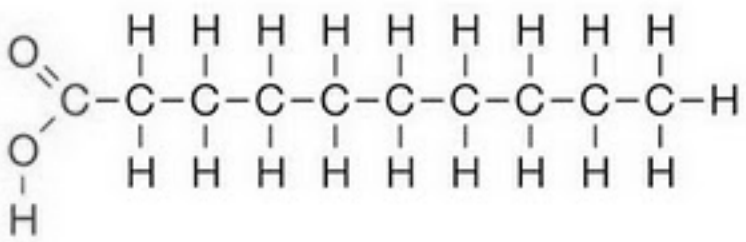


FATTY ACIDS

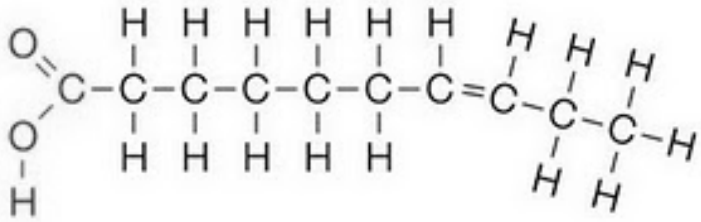


TRIGLISERIDA

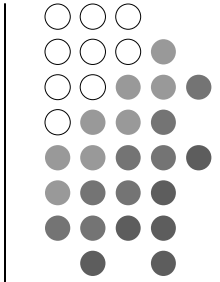
Saturated



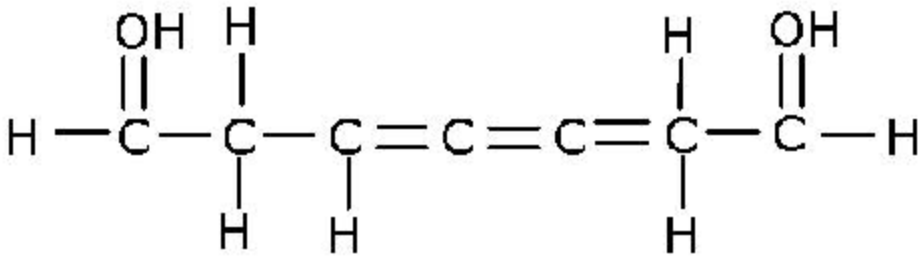
Unsaturated



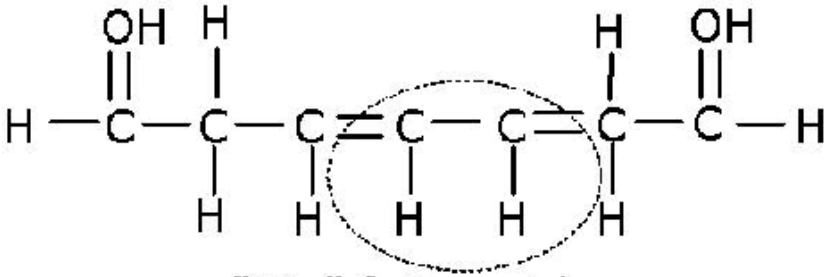
- Fatty acids: chains of 4 – 28 carbon atoms with the carbon chain joined by single or double bonds, depending on the number of hydrogen atoms attached.
- Saturated and unsaturated fatty acids.
- The acid portion of a fatty acid (FA) is represented by COOH.



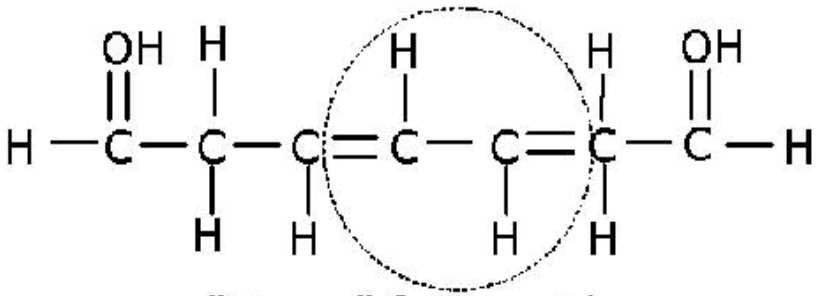
- If a FA contains a double bond, the H atom/ other group attached to the carbon atoms involved in the double bond may have different orientation --- as cis or trans forms (isomers)
- Cis and trans forms show different geometrical arrangement and give a fatty acid different chemical and physical properties.



Polyunsaturated fatty acid



"Cis" fatty acid



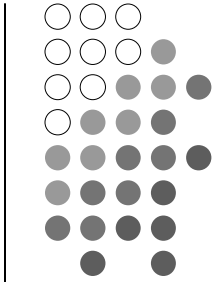
"Trans" fatty acid

Nutrition Facts

Serving Size 1 cup (200g)

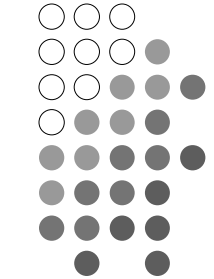
Amount Per Serving	
Calories 260	
	% Daily Value
Fat 13g	20%
Saturated Fat 3g + Trans Fat 2g	**25%**
Cholesterol 30mg	10%
Sodium 660 mg	28%
Carbohydrate 31g	10%
Fiber 0g	0%
Sugars 5g	
Protein 5g	
Vitamin A 4%	Vitamin C 2%

Influence of the size of FA & saturation on the melting point (1)



Fatty Acid	No. of carbon atoms	Melting point (ºC)
Saturated Fatty Acid		
Butyric	4	-7.9
Caproic	6	-3.9
Caprylic	8	16.3
Capric	10	31.3
Lauric	12	44.0
Myristic	14	54.4
Palmitic	16	62.8
Stearic	18	69.6

Influence of the size of FA & saturation on the melting point (2)



Fatty Acid	No. of carbon atoms	Melting point (°C)
Unsaturated Fatty Acid		
Palmitoleic	16	-0.5 – 0.5
Oleic	18	13.0
Linoleic (trans)	18	-5 – (-12)
Linolenic (cis)	18	-14.5
Arachidonic	20	-49.5

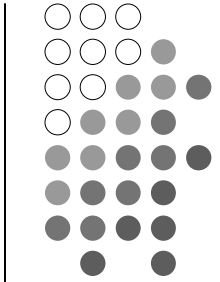
Influence of the size of FA & saturation on the melting point (3)

- A longer carbon chain increases the melting point.
- The more double bonds, the lower the melting point.
- Cis fatty acids have a lower melting point than trans.

Fat	Solid Fat Index at °C					Melting Point (°C)
	10	21	27	33	38	
Butter	32	12	9	3	0	36
Cocoa butter	62	48	8	0	0	29
Coconut Oil	55	27	0	0	0	26
Lard	25	20	12	4	2	43
Palm Oil	34	12	9	6	4	39
Palm kernel oil	49	33	13	0	0	29
Tallow	39	30	28	23	18	48

Potter & Hotckiss (1996)

SOURCES



- **Vegetable Oils**
  - Soybean, palm oil, rapeseed/canola, sunflower, cottonseed, peanut, sesame, corn, olive, coconut, cocoa butter etc.
- **Animal Fats and Marine Origins**
  - Butter (from milk), lard (from hogs), tallow (from beef), fish oil (cod, whale, etc.)

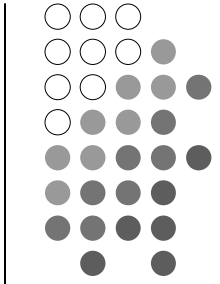
80% of total oil and fat production is used for food --- frying oils, baking fats, cooking fats, shortenings, spreads, salad oils, mayonnaise, confectionery fats, & ice cream

Consumption of oils and fats for food and non-food purposes in selected countries in 1990/2000 and 2004/2005

	World	USA	EU-25	China	India
Personal (kg/person/year)					
1999/00	18.4	49.9	43.2	13.6	11.4
2004/05	21.0	49.0	50.2	19.6	11.7
Total (million tonnes/year)					
1999/00	113.4	15.7	17.1	14.7	6.6
2004/05	136.4	15.5	17.4	18.0	8.0

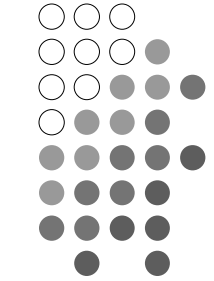
Source: Anon (2005).

What properties are desired?



- Physical
- Chemical
- Nutritional
- Functional

Physical Properties of Oils & Fats (1)



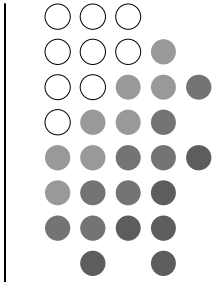
- Thermal properties:
  - crystallization & melting
  - the formation of solid and liquid
  - the behaviour of plastic fats that are mixtures of solid and liquid components
- Mandatory, example:
  - salad oils do not contain lipids that will crystallize during storage in a refrigerator.
  - Most frying oils and oils used as food coatings (and lubricants) should also be free of solid components

Physical Properties of Oils & Fats (2)

- Spreads:
  - depends on having appropriate levels of solid fat at refrigerator temperature, at ambient temperature and at mouth temperature.
  - The solid fat content at 4 °C should not exceed 30–40 % (to be spreadable from the refrigerator); at 10 °C it should be 10–20 % (the fat will ‘stand up’ --- not collapse to a puddle of oil).

→ Crystalline form of triacylglycerols

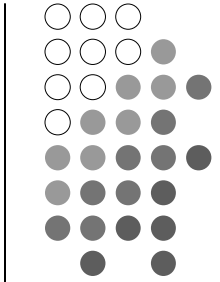
Chemical Properties of Oils & Fats



- Food lipids are not usually considered to require defined chemical properties, but without oxidative stability of their lipid components foods would quickly become rancid and have a short shelf life.

- For this reason they should be oxidatively stable. This can be determined by the peroxide value of fats/oils. This indicates the degree of oxidation that has been taken place in a fat/ oil.

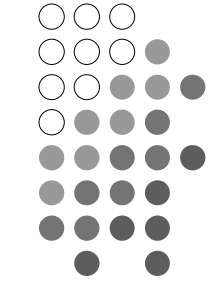
Chemical Properties of Oils & Fats



- Iodine value – express the degree of unsaturation of the FAs in the fat (the amount of iodine absorbed by a fat/100 g basis). The higher iodine value indicates the greater the degree of unsaturation.

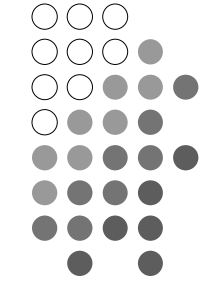
- Hydrolytic rancidity refers to the rancidity that occurs under conditions of moisture, high temperature, and natural lipolytic enzymes. The **acid value** represents **free fatty acids** in fat that were released during hydrolysis.

Chemical Properties of Oils & Fats



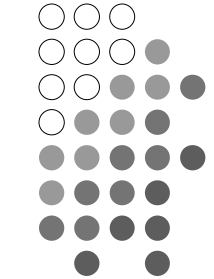
- Saponification value indicates the average molecular weight of fatty acids in a fat.

Nutritional Properties of Oils & Fats (1)



- The total level of fat in a food
- An appropriate balance between saturated, monounsaturated and polyunsaturated acids is desirable:
  - The content of saturated fatty acids --- SFA raise the serum cholesterol levels
  - Among monounsaturated acids a clear distinction must be made between *cis* and *trans* isomers with the former being cholesterol-lowering and the latter cholesterol-raising --- lower trans fatty acid trend

Nutritional Properties of Oils & Fats (2)



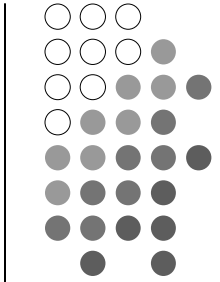
- The quota for polyunsaturated fatty acids. In particular, the ratio of omega-6 to omega-3 acids should be between 5 and 10 to 1 (or less). Since the presence of α-linolenic acid leads to oxidative instability and reduced shelf life.
- Fats and oils have a high caloric value, 2.25 times more energy than carbohydrates or proteins.
- Each gram of fat contains 9 kcal of energy.
- Fats and oils carry the fat soluble vitamins.

Functional Properties

- Textural qualities (body and mouthfeel)
- Emulsions
- Shortening or tenderizers
- Medium for transferring heat
- Aeration and leavening
- Spray oils

- Producing satiety (fullness after eating)
- Adding flavor
- Decreasing temperature shock in frozen desserts
- Foaming
- Solubilizing flavors and colors

Major vegetable sources of food lipids

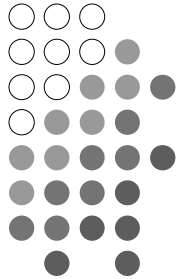


- The major vegetable oils are pressed and/or extracted from seeds or pressed from fruits.
- The major sources come from soybean, palm, rapeseed/canola, sunflower seed, coconut and others.

Soybean Oil

- The major fatty acids in soybean oil are linoleic (53 %), oleic (23 %), palmitic (11 %), linolenic (8 %) and stearic (4 %) (Wang, 2002).
- A healthy oil, low in saturated acids and rich in polyunsaturated fatty acids (PUFA), especially linoleic acid.
- Soybean oil in its native but refined form or in some partially hydrogenated form is widely used for food purposes such as frying and salad oils, margarine and shortening, and mayonnaise and salad dressing.

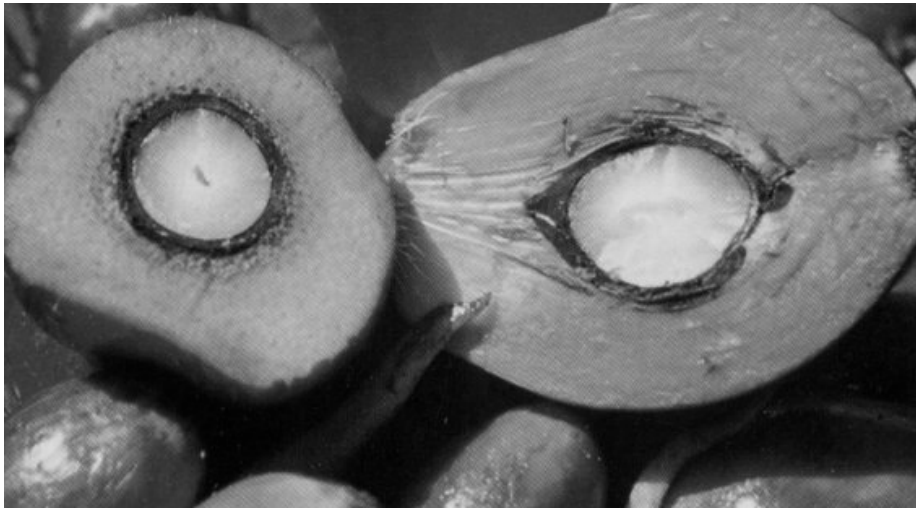
Palm Oil



- The oil palm produces two different oils – palm kernel oil and palm oil.
- Malaysia and Indonesia are the major producing and exporting countries of palm oil.
- Palm oil is considered as a saturated fat in comparison to the more highly unsaturated vegetable oils.
- The oil is rich in nutritionally important minor components.
- Because of its fatty acid composition and its minor components which act as antioxidants, palm oil has high oxidative stability.

Palm Oil

- Palm oil is used for a wide range of food purposes including frying, in spreads and in shortenings.
- Palm olein is a major frying oil, and palm stearin finds increasing use as hard stock in fat blends which are interesterified to produce spreads with no hydrogenated oil and therefore containing little or no *trans* acids.



Rapeseed/Canola Oil

- Rapeseed and canola are terms describing the seed and extracted oil from *Brassica* species including *B. napus* (formerly *B. campestris*), *B. rapa* and *B.juncea*.
- The seed oil from these species was typically rich in erucic acid (22:1), and the seed meal had an undesirably high level of glucosinolates.
- Typically it contains palmitic (4 %), stearic (2 %), oleic (62 %), linoleic (22 %) and linolenic (10 %) acids and has less saturated acids than any other commodity oil.

Rapeseed/Canola Oil

- With its low level of saturated acids, its high level of oleic acid and the presence of linoleic and linolenic acids at a favourable ratio (~ 2:1) rapeseed oil rates highly in the classification of healthy oils.
- The oil is used as a salad oil and salad dressing and mayonnaise, in margarine and other spreads, as a frying oil, and in many minor food applications.

Sunflower Seed Oil

- Oil obtained from sunflower seeds (*Helianthus annuus*)
- Sunflower oil is available in three ranges of fatty acid composition. The traditional and still major sunflower oil is linoleic-rich, but two other forms have been produced by conventional seed breeding; these are a high oleic oil and a mid-oleic oil.
- Crude sunflower oil contains phospholipids (0.7–0.9 %), tocopherols (630–700 ppm), sterols (~ 0.3 %) and carotenoids (1.1–1.6 ppm).

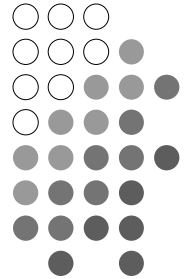
Sunflower Seed Oil

- The seeds are also a rich source of selenium compared to most other seeds and nuts.
- Sunflower seed oil contains some wax (esters of longchain alcohols and long-chain acids) coming from an outer protective seed coat, which makes the oil appear cloudy.
- The oil is to be used as a salad oil.

Lauric oils (coconut, palmkernel)

- Coconut oil and palmkernel oil are similar to one another in their fatty acid composition.
- Both have high levels of medium-chain saturated acids, especially lauric acid (12:0), hence the term lauric oils.
- They have only low levels of unsaturated C18 acids and low iodine values.
- They are used extensively both as food and as non-food oils and serve as the major source of C8 (caprylic or octanoic) acid and C10 (capric or decanoic) acid.

Other vegetable food oils



- All the other oils are rich in oleic and/or linoleic acid.
- Cottonseed and rice bran oils have higher levels of palmitic acid than is usual in vegetable oils.
- Linseed is used mainly as an industrial oil.
- Groundnut (peanut), cottonseed and corn oils are used for the usual range of foods (frying, baking, salad oils, etc.) and may be partially hydrogenated, fractionated or interesterified to improve their properties for these purposes.

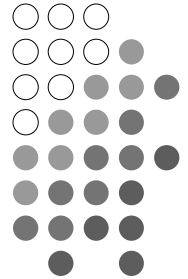
Other vegetable food oils

- Olive, sesame and rice bran oils are more usually used without modification as liquid oils.
- Sesame and rice bran oils are marked by high oxidative stability property.

Major sources of animal fats

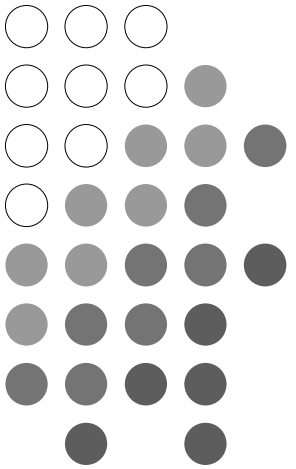
- There are two major sources of land animal derived lipids used for human nutrition: the lipids in animal body tissues, commonly referred to as animal fats or meat fats, and the milk lipids.
- The technical term ‘animal fats’ or ‘meat fats’ actually refers to fat obtained from adipose tissues of land animals by a process called rendering.

Major sources of animal fats

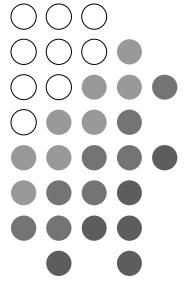


- Fat is typically deposited in the abdominal cavity, particularly around the kidneys and the stomach (internal fat), peripheral under the skin (subcutaneous adipose tissue), between muscles and between muscles and bones (intermuscular fat) and within skeletal muscles (intramuscular fat).

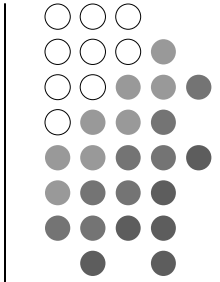
PRODUCTION & PROCESSING METHODS



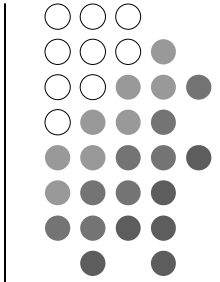
REFINED OILS (VEGETABLES)



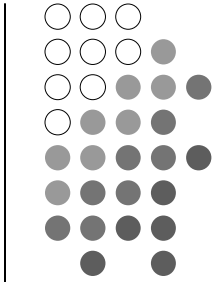
- DEGUMMING
  - The first step in refining process of many oils.
  - Oils are degummed by mixing oils with water
  - This processed may be enhanced by adding phosphoric or citric acid or silica gel.
  - It removes valuable emulsifiers such as lecithin.
  - It is required for soybean and canola oils production.



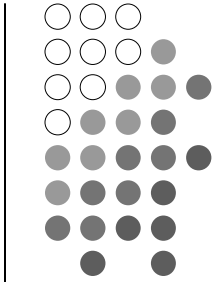
- ALKALI REFINING
  - The gummed oil is then treated with an alkali to remove free fatty acids, glycerol, carbohydrates, resins, metals, phosphatides, and protein.
  - The oil and alkali are mixed, allowing FFA and alkali to form a soap.
  - The soap is then removed by centrifugation.
  - Residual soaps are removed with hot water washings.



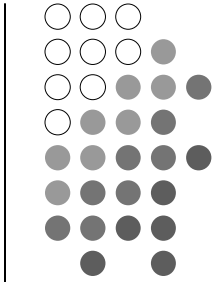
- BLEACHING
  - The removal of trace metals, color bodies such as chlorophyll, soaps, and oxidation products using bleaching clays, which absorb the impurities.
  - Bleached oils are nearly colorless and have a peroxide value of near zero.



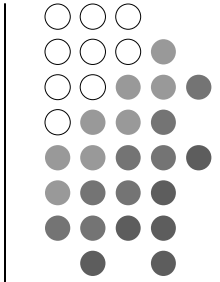
- WINTERIZATION/ FRACTIONATION
  - Oils destined used for use as salad oils, or oils that are to be stored in cool places, undergo a process winterization so that they will not become cloudy when chilled.
  - The refined oils are chilled with gentle agitation, which causes higher melting fractions to precipitate.
  - Canola, corn, cottonseed, sunflower, safflower, and peanut oils must be winterized to be clear.



- HYDROGENATION
  - Treatment of fats and oils with hydrogen gas in the presence of a catalyst in the addition of hydrogen to the carbon-carbon double bond.
  - Hydrogenation produces oils with mouthfeel, stability, melting point and lubricating quality necessary to meet the needs of many manufacturers.
  - Hydrogenation can be controlled to produce various levels of hardening, from very slight to almost solids.

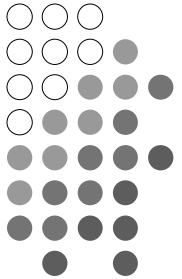


- DEODORIZATION
  - A steam destillation process carried out under a vacuum, which removes volatile compounds from the oil.
  - The end product is a bland oil with a low level of FFA and zero peroxide value.
  - This step also removes any residual pesticides or metabolites that might be present.
  - Deodorization produces some of the purest food products available to consumers.



- INTERESTERIFICATION
  - This process allows fatty acids to be rearranged or redistributed on the glycerol backbone.
  - This is most often accomplished by catalytic methods at low temperatures.
  - The oil is heated, agitated, and mixed with the catalyst at 90^{o}C. Also enzimatic system may be used for intersterification.
  - It will improve the functional properties of the oil.

ANIMAL FATS



- Animal fats are produced by rendering – melting animal fat to extract.
- Rendering can be accomplished by heating meat scraps in steam or water and then skimming or centrifuging to separate the fat.
- Dry heat and a vacuum can also be used to render fat.
- The temperature used to render fat can influence its color and flavor.

References

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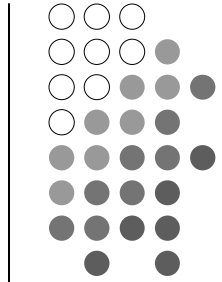

Thank You…