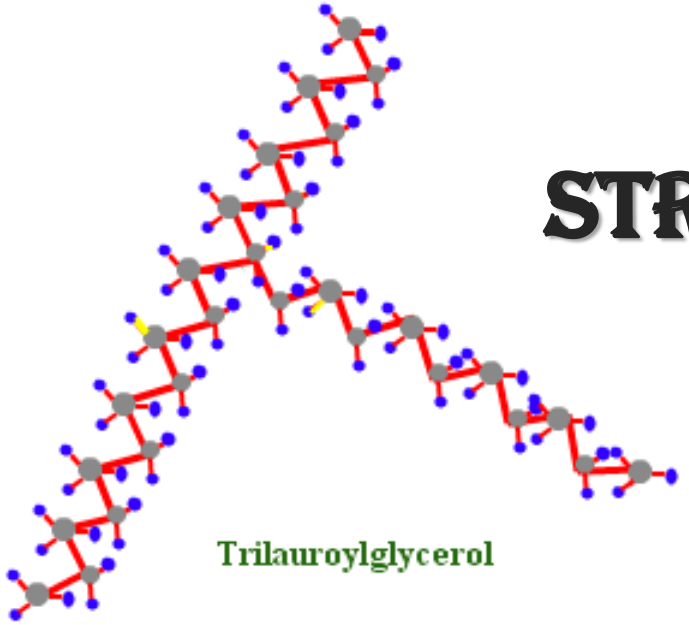

FATS AND OILS: STRUCTURES AND FUNCTIONS

MPOC

By

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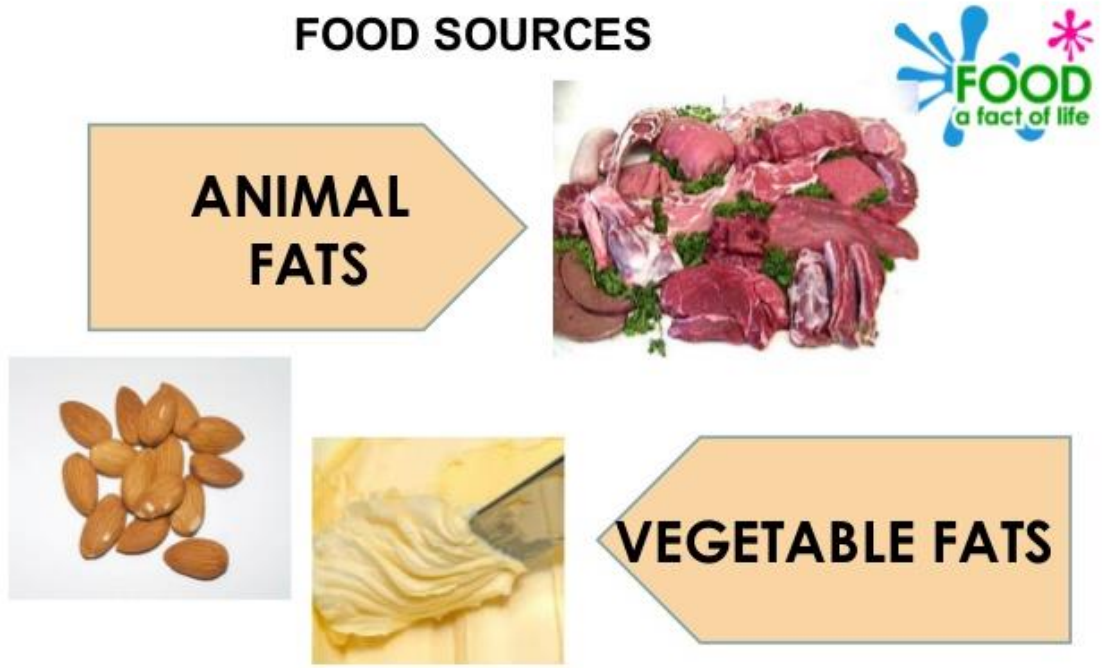
Introduction

Today, we drink low-fat milk and eat leaner meats,
but we eat more fat from creams, cheese, sauces, and take-out foods.



FOOD SOURCES

FOOD
a fact of life

ANIMAL FATS

VEGETABLE FATS

FOOD
a fact of life

VISIBLE FATS

INVISIBLE FATS

The Functions of Lipids and Fats?

- **Lipids, a chemical family that includes cholesterol, phospholipids, fats and oils, make up a major part of the average human diet.**

What role do dietary fats play in the diet?

- The fats that we get from food are vital to good health.
- They provide energy and essential fatty acids for healthy skin and important hormone-like substances.
- Fats also carry and help the body absorb the fat-soluble vitamins A, D, E and K.

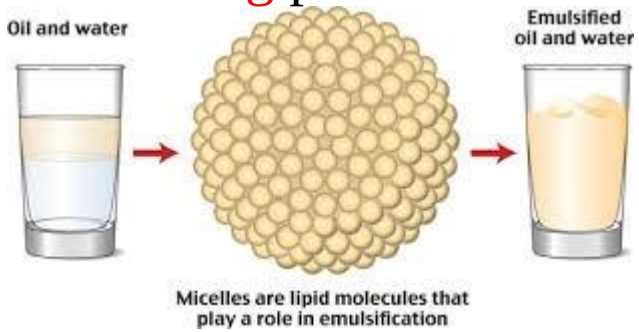
What's more, dietary fats help us feel satisfied following meals.

- Fats and oils are not just a caloric powerhouse,
- but they also serve many:
- Chemical, Physical, and Nutritional
- Functions in the foods we eat.

Ten of the Most Important Functions That Fats Serve in Food

1. Appearance

- Fats and oils can alter a food's appearance by creating a glossy or moist visual texture.
- The ability of fat to refract light is also responsible for the opaque appearance of milk.
- Fats also aid in the browning process of many foods, giving them an appealing golden brown color.



2. Emulsions

- Fats and oils are an important component in most emulsions.
- Emulsions are the dispersion of a fat or oil into water (or vice versa) O/W or W/O.
- There are many emulsions in the culinary world including salad dressings, mayonnaise and cheese sauces.
- Emulsifying fat into a liquid produces unique flavor and texture qualities.

3- Flavor

- Fat has the unique ability to absorb and preserve flavors.
- Fats also contain compounds that lend specific flavors of their own.
- The way fat coats the tongue and allows flavors to linger can also alter

a flavor experience.

The species-specific flavors of meats are carried in their lipids; the flavors of beef and lamb are indistinguishable, if the lipids are stripped from the meats.

4- Heat Transfer

- Fats provide one of the most efficient modes of heat transfer during cooking.
- From deep fat frying to sautéing in a skillet or wok, hot oil is able to transfer high levels of heat to the surface of food without overheating the interior portions.
- Using fats and oils to transfer heat also facilitates crust formation.

5- **Melting Point**

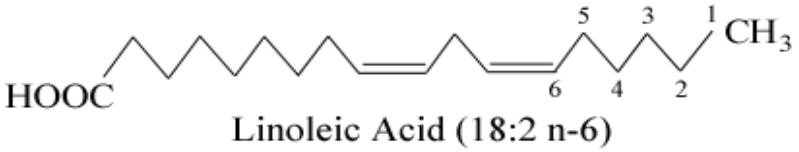
- The type of fat used in a product often determines the melting point of the final product.
- A melting point is the temperature at which a substance changes from a solid to a liquid.
- This characteristic is especially important for items like chocolate, frosting, and salad dressings.
- Saturated fats, like butter and animal fats, are solid and room temperature, which make them perfect for using solid foods like chocolate and frosting.
- The low melting point of vegetable oils allows salad dressings to stay in liquid form when refrigerated.

6- **Nutrition**

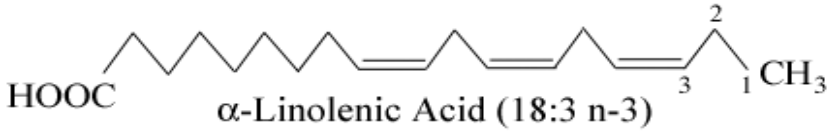
- Fats are the most calorie dense compound in food, weighing in at over twice the calories per gram of proteins or carbohydrates.
- While this may not be seen as an advantage in today's modern society, the ability to provide energy dense food items is still necessary in many parts of the world.
- Fat is an effective method of delivering calories when needed.
- Fats are also important for delivering fat-soluble vitamins such as Vitamins A, E, D, and K.

- Essential fatty acids are precursors to EPA and DHA which manufacture
  - Prostaglandins
  - Thromboxanes
  - Leukotrienes

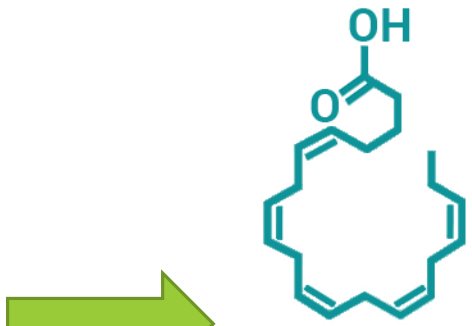
  → Regulate the immune system
  → Regulate blood clotting
  → Regulate inflammation
  → Regulate blood pressure



Linoleic Acid (18:2 n-6)

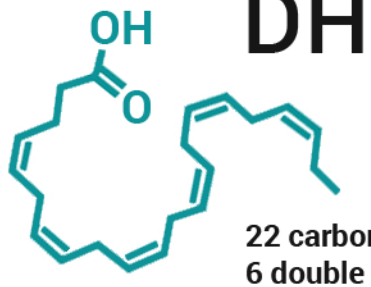


α-Linolenic Acid (18:3 n-3)



EPA

20 carbon
5 double bonds



DHA

22 carbon
6 double bonds

7- Satiety

- Fats play an important role in making foods satisfying or making us feel full.
- Because fats take longer to digest than carbohydrates or proteins, high-fat foods stay in the stomach longer and delay the feeling of hunger.

8- Shortening

- Shortening is not just the name of a solid, shelf stable fat but it is also the term used to describe fat's ability to make baked goods tender by impeding the formation of gluten strands.
- Normally, as bread dough is kneaded the gluten (wheat protein) begins to join and form long elastic strands, which give strength and a chewy texture to the bread.
- When fat is added to dough, like in biscuits and pie crusts, the fat gets in the way of the gluten formation, therefore keeping the final product tender and flakey.

9- **Solubility**

- While fats and oils are not soluble in water, there are other chemical compounds that are only soluble in fats.
- Many of these fat-soluble compounds are responsible for foods flavor and even vitamin content.
- Including fat in food allows for maximum flavor and a wider range of nutritional content.

10. Texture

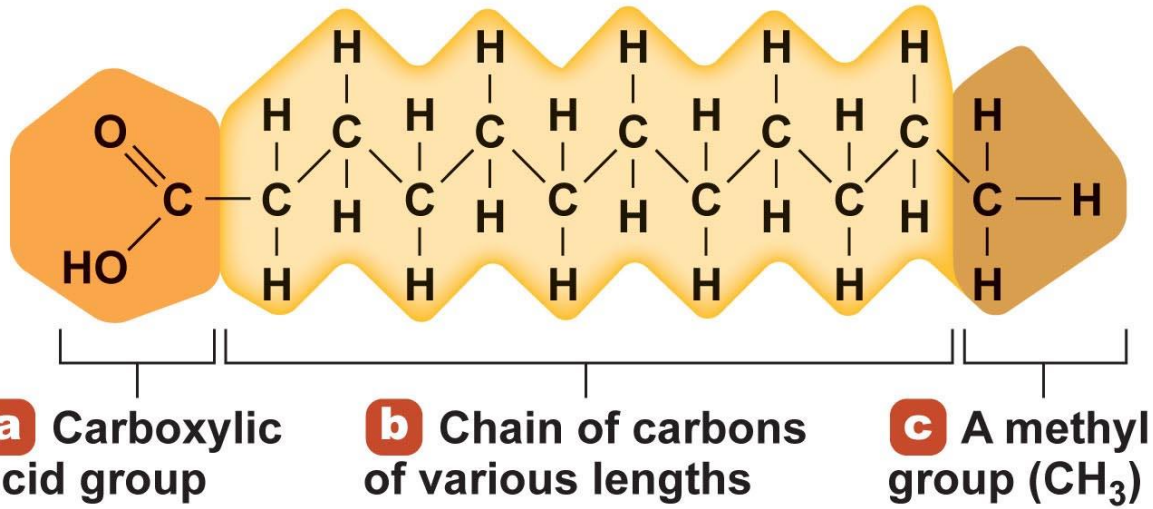
- Fats and oils have a texture all their own but are also responsible for tenderizing baked goods via the shortening process.
- Fat provides a very specific, lubricating mouthfeel, which is why most dry crackers or chips are served with high-fat content dips or spreads.

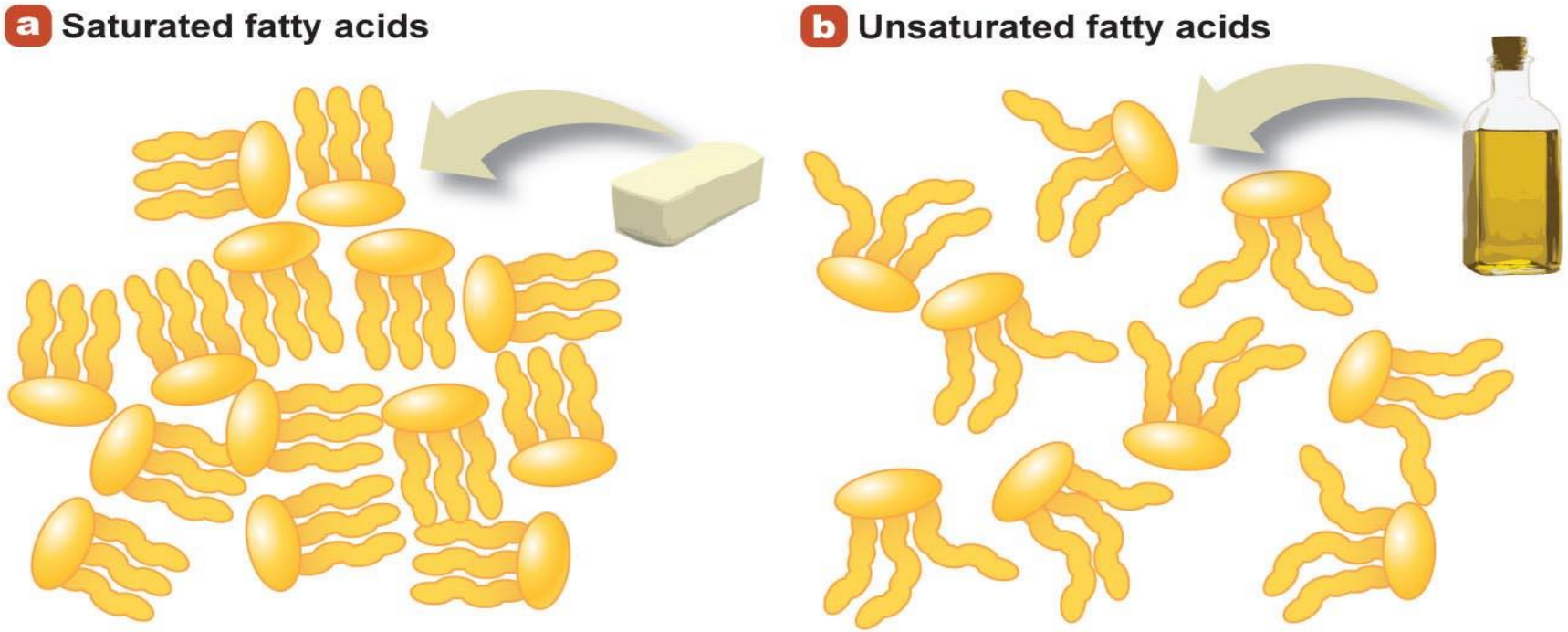
Fats and Oils Structure and Function

- Emerging information on changing technologies, uses and health benefits of this macronutrient is provided.
- The structure of lipids affects their nutritional and functional properties.
- The types of fats and oils used in formulations have specific impacts on sensory, nutritional and functional aspects of finished products.

Function Follows Form

- The structure of the lipid determines its function in the cell.
- Most of the lipids that have value for food products are in the triglyceride, energy-storage form.
- Triglycerides are composed of three fatty acids attached by an ester linkage to a glycerol backbone.
- The order in which the fatty acids are attached to the glycerol backbone is highly structured in nature.





Fatty Acids Vary in Shape

Unsaturated fatty acids form two different shapes

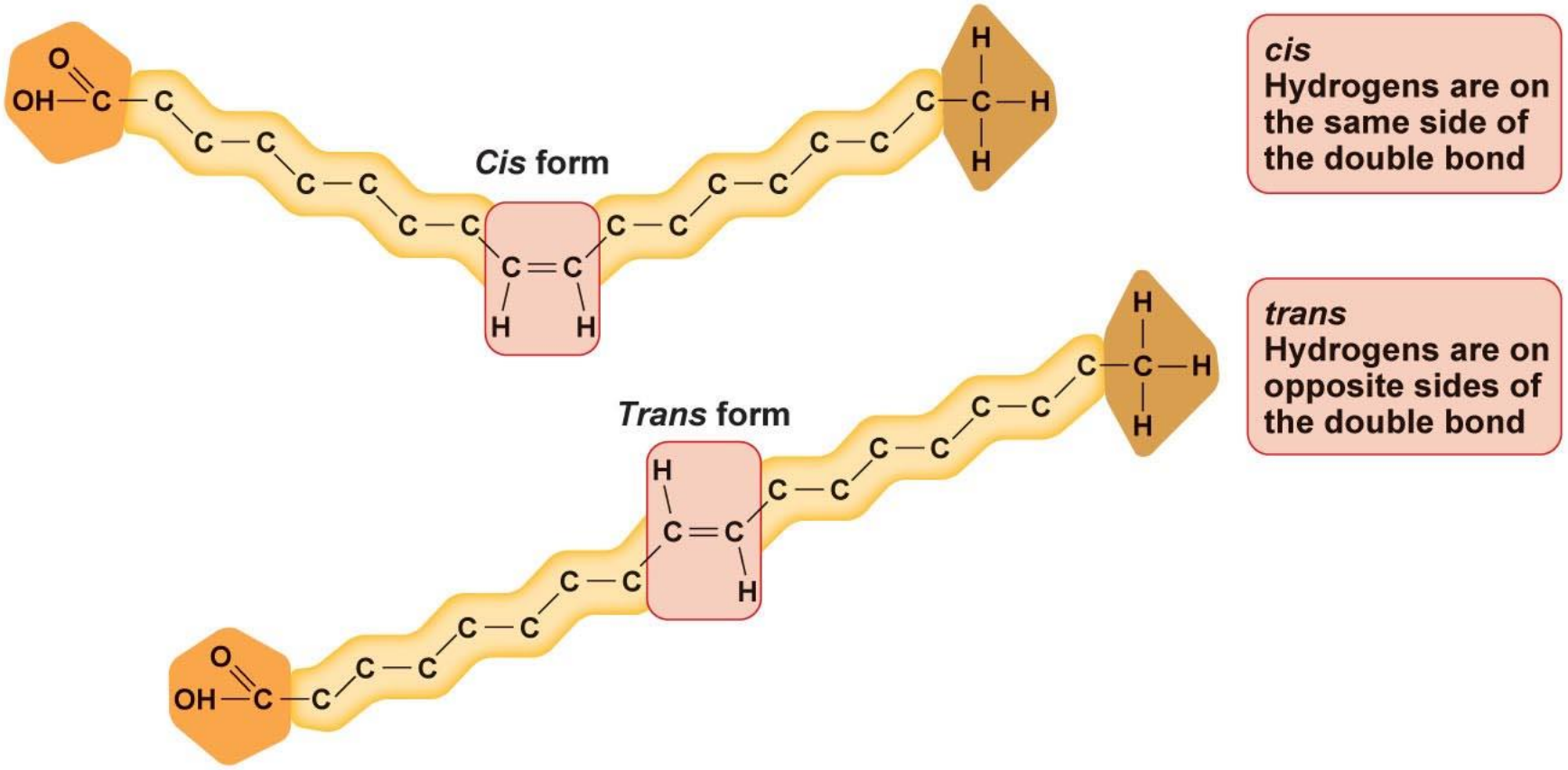
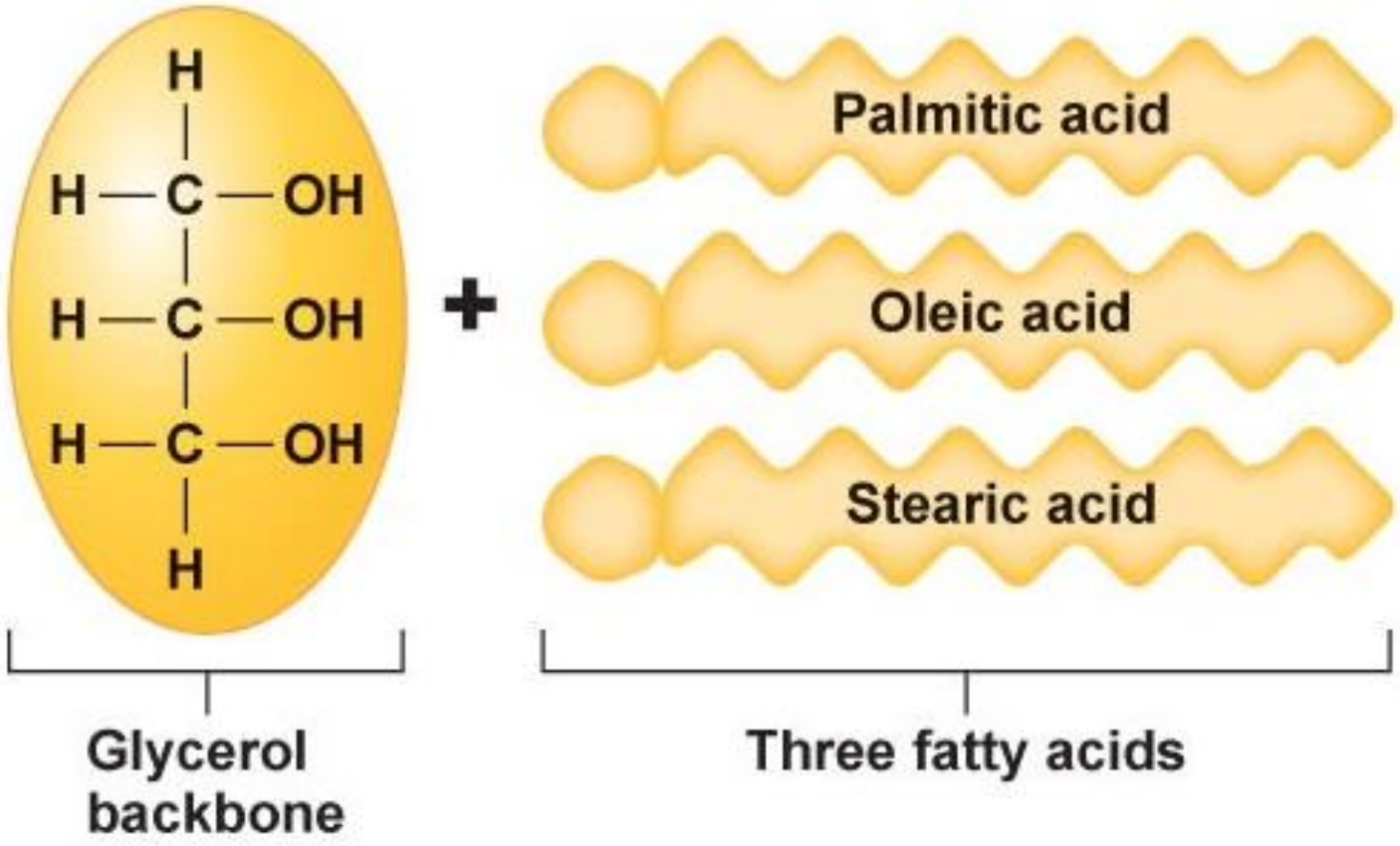


Figure 5.5

Triglycerides

Three fatty acids connected to a glycerol backbone



Portion of Figure 5.7

Triglycerides--Functional Fats/Shortenings

- The difference between fats and oils is driven by their fatty acid composition and the arrangement of the fatty acids in the triglyceride molecule.
- Fatty acid chain length and the number and placement of double bonds in the fatty acid chain determine the melting profile of fats and oils.
- The melting profile determines the functionality and sensory characteristics of a fat.

  As an example, properly crystallized cocoa butter in chocolate has a sharp melting point slightly below body temperature, which gives chocolate its unique properties of melting and cooling on the tongue.
- The fatty acid composition of cocoa butter is about two thirds saturated fatty acids (palmitic and stearic acids) and one third unsaturated (oleic with a small amount of linoleic acid).

- Choosing solid shortenings for food applications is more complicated than liquid oils, as the shortening's structure impacts its function, such as flaky texture in pastry and smooth mouthfeel in breads.
- Solid shortenings range from very hard and highly saturated to very soft and plastic with a high degree of unsaturation.

- For many years, much of this functionality was achieved through the use of **trans fats**.
- Trans fats are unique, in that they are unsaturated lipids that function much like their saturated counterparts.
- While small amounts of trans fats are naturally occurring in some foods, such as butter, they primarily are produced through partial hydrogenation of unsaturated oils, such as soybean oil.

- As the food industry rapidly moved away from using **trans fats** because of perceived health concerns, lipid scientists had to scramble to find replacements that provided the unique functionality that trans fats offered.

Palm and palm kernel oils have become the primary sources for zero-trans alternative shortenings.

- This is because they have a high degree of shorter-chain saturated fatty acids, with lower melting points, that can be manipulated to provide crystalline structure with a range of melt profiles.

- The move to palm-based shortenings:

fats and oils manufacturers now have built much of the functionality into palm-based shortenings, to the point that they are now comparable to their trans counterparts.

- This has been done through **fractionation** and recombination of the triglycerides, along with rearrangement of the fatty acids on the triglyceride molecules.
- While palm-based shortenings now are working well in foods, there continue to be concerns around their saturated fat content.

- Recently, palm-based shortenings are being transformed from containing as much as 64-69% saturated fat to as low as 24-46% saturated fat with equal functionality.
- This is being done by using unsaturated fractions of soybean and canola oils in combination with inter esterified palm fats.

Oil palm, is a unique crop as its fruit produces two distinct types of oils;

Crude palm oil from the mesocarp & Crude palm kernel oil from the kernel.

FRACTIONATION PROCESS

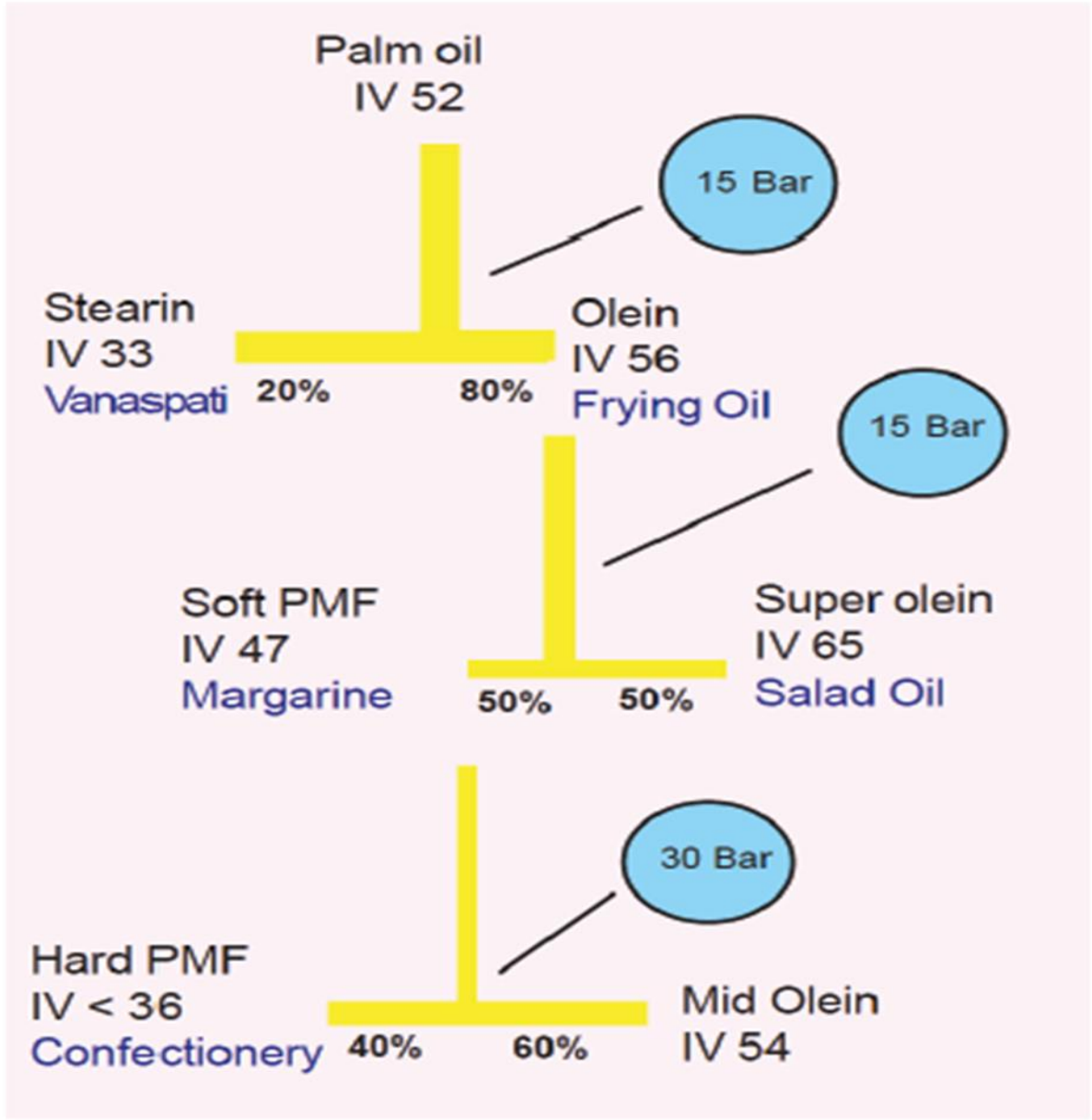
From Refining Process

RBD Palm Oil

RBD Palm Kernel Oil

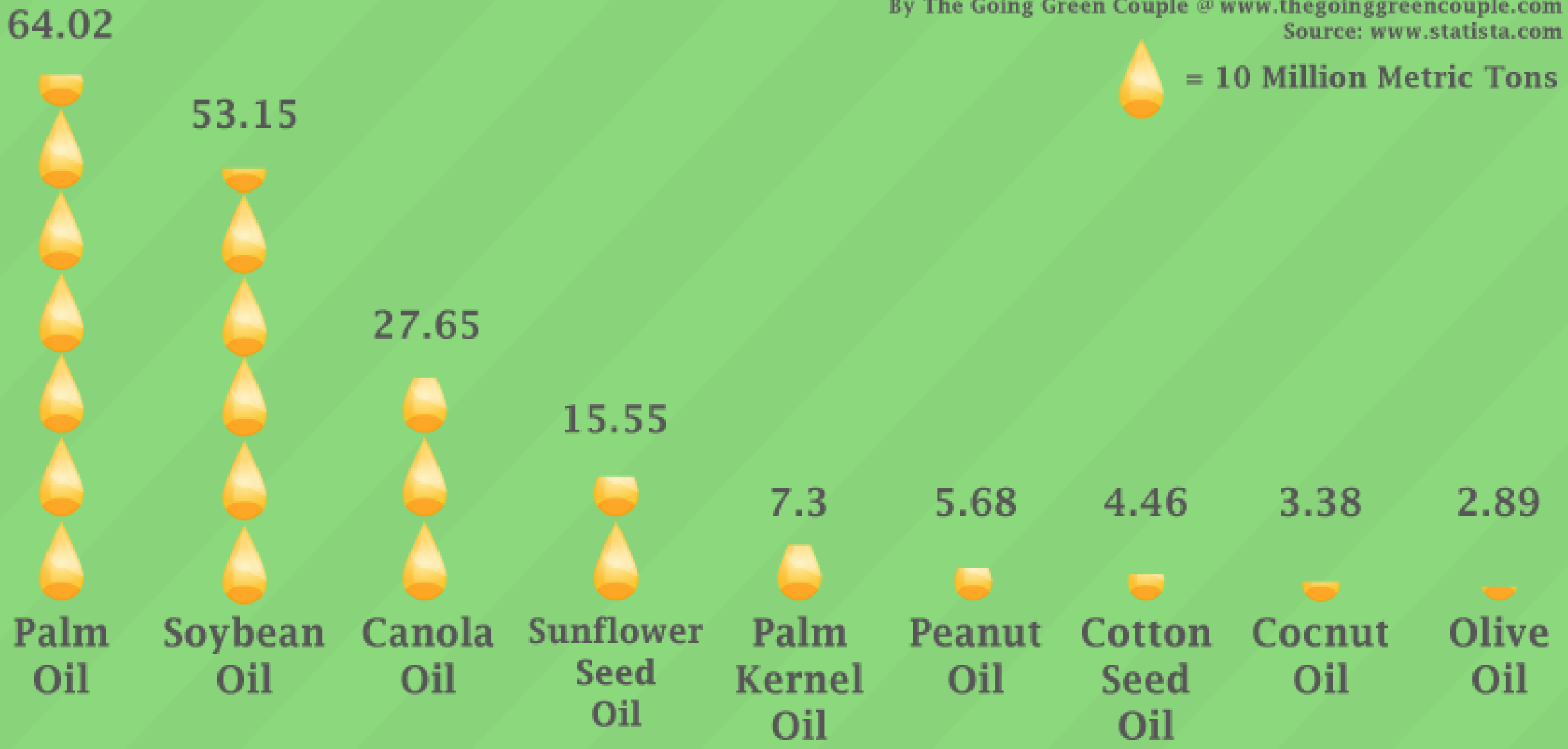
Fractionation Process (physical process)

Multiple dry fractionation route for palm oil



2016/2017 Global Edible Oil Production

By The Going Green Couple @ www.thegoinggreencouple.com
Source: www.statista.com



Conclusion:

- **The structure of the lipid determines its function**
- The roles of fats and oils play in food products and in human nutrition continue to grow and change.
- Above all, it's important to remember that the principles of balance, variety and moderation form the basis for a healthful diet. Along with appropriate amounts of whole grains, vegetables, fruits,

Recommendation:

- The cooperation between the food manufacturer with food scientists and nutritionists is resulting in producing more healthful, satisfying food products.

References:

Wendy M. Willis, Robert W. Lencki, and Alejandro G. Marangoni. Lipid Modification Strategies in the Production of Nutritionally Functional Fats and Oils. Critical Reviews in Food Science and Nutrition, 38(8):639–674 (1998)

Beermann, C. et al. 2003. Lipids Health Dis. 2:10.

Dean, W., and English, J. 2010. Nutrition Review. www.nutritionreview.org/library/mcts.php.

Gaullier, J.M. et al. 2004. Am J Clin Nutr. 79:1118-1125.

Larsson, K. et al, 2006. Lipids: Structure, Physical Properties and Functionality: Volume 19. The Oily Press Lipid Library.

Stauffer, C.F. 1996. Fats & Oils. Eagan Press, St. Paul, MN, U.S.

Tricon S., et al. 2004. Am J Clin Nutr. 80: 614–20.

Zeisel, S.H. 2000. J Am Coll Nutr. 19:528S-531S.

Zulet, M.A., et al. 2005. J Physiol Biochem. 61: 483–94.

Thanks
For
Your Attention