Overview of the food science behind fatty acid technology

Pamela J. White, Ph.D.
Food Chemist/Scientist
Food Science and Human Nutrition Dept.
& Center for Crops Utilization Research
Iowa State University
Ames, Iowa

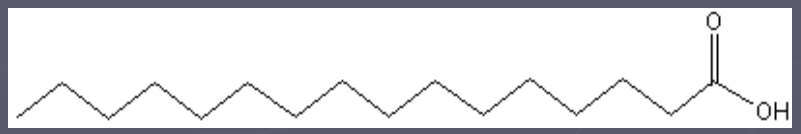
CCUR

Food Science & Human Nutrition
Iowa State University

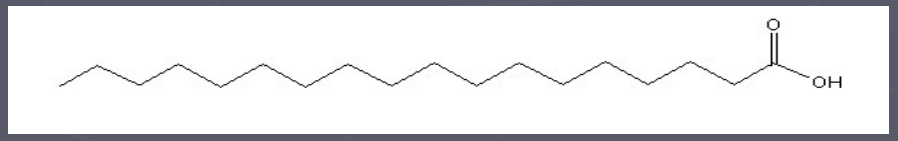
Presentation outline

- Structures of fatty acids (FA)
- Functions of FA in foods
- Processes to reduce trans FA
- Methods to measure trans FA
- Choices of fat/oil for specific uses

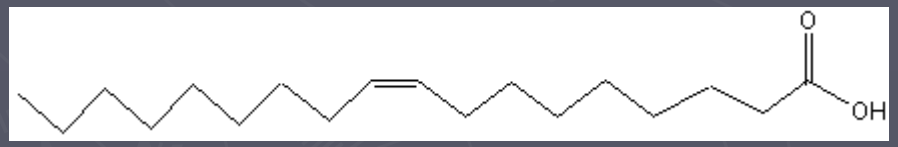
Major FA in fats and oils



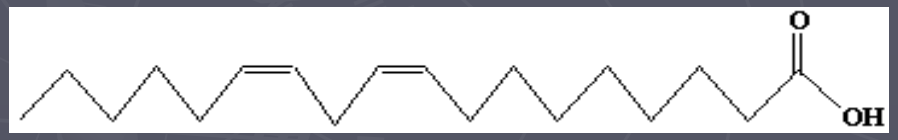
- 16:0, Palmitic acid



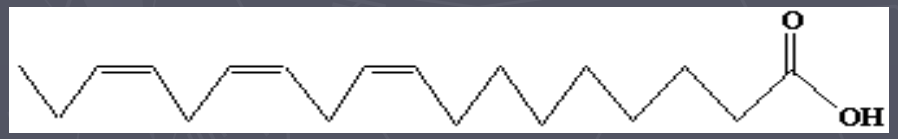
- 18:0, Stearic acid



- 18:1, Oleic acid



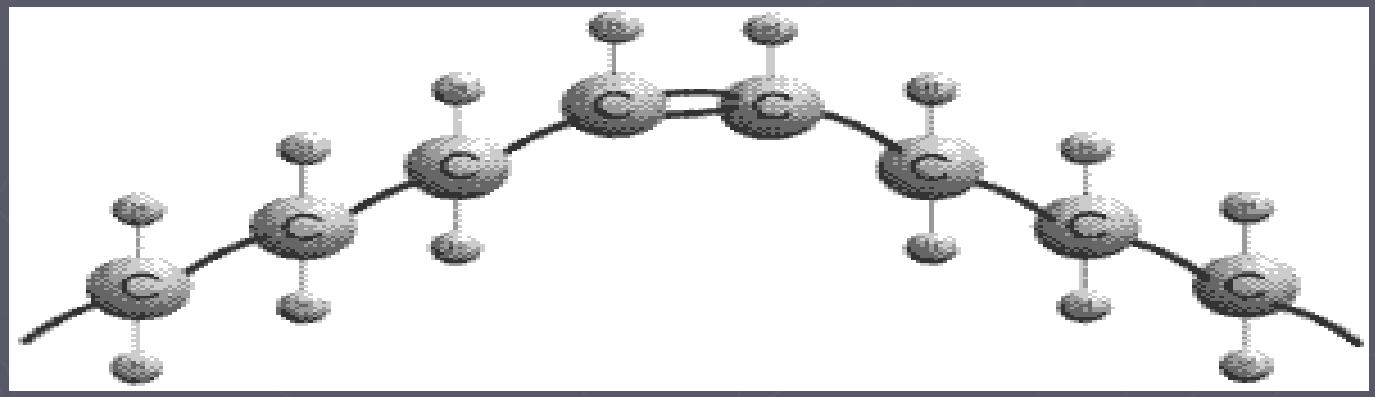
- 18:2, Linoleic acid

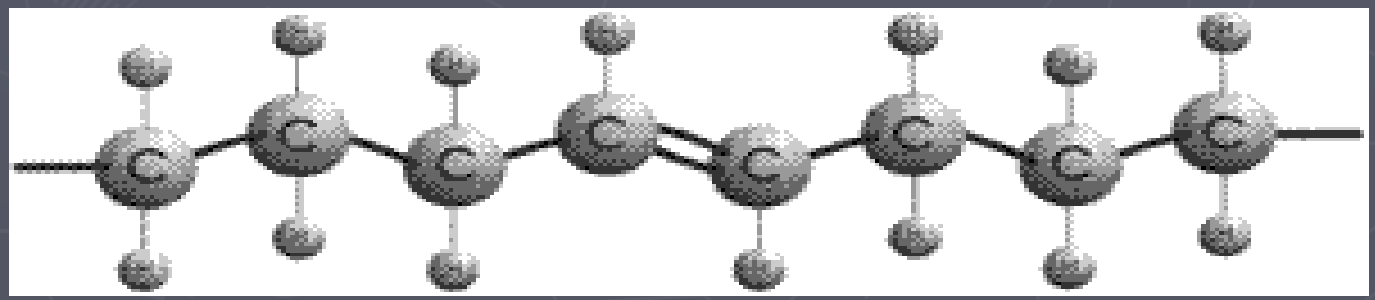


- 18:3, Linolenic acid

cis and trans molecular arrangements

Functional differences: trans more solid than cis, but less solid than saturated





http://www.iseo.org/ffo_1-4.htm

Institute of Shortening and Edible Oils

Functions of palmitic acid (saturated)

- Very stable
  - In storage
  - During frying
- Functions in foods
  - Solid to form margarines, shortenings
  - Promotes smooth β' crystals
  - Spreads for bread
  - Creaming for baked products
- BUT, ↑ LDL-cholesterol, ↑ heart disease

Functions of stearic acid (saturated)

- Very stable
  - In storage
  - During frying
- Functions in foods
  - Solid to form margarines, shortenings
  - Spreads for bread
  - Creaming for baked products
- Neutral health benefits

Functions of oleic acid (monounsaturated)

- Stable
  - In storage
  - During frying
- Functions in foods
  - Liquid at room temperature
- Neutral to positive health: ↑ HDL-cholesterol (good), ↓ LDL-cholesterol
- BUT, if too high, poor flavor

Functions of linoleic, linolenic acids (polyunsaturated)

- Functions in foods
  - Liquid at room temperature
- Linoleic: omega-6; Linolenic: omega-3
- BUT, unstable in storage and frying
  - Linoleic: small amount okay for flavor
  - Linolenic: main source of off-flavors, rancidity
- ↓↓ Total and LDL-cholesterol, ↑HDL-cholesterol

Functions of trans FA

- Stable
  - In storage
  - During frying
- Functions in foods - more solid than cis unsaturated, but less solid than saturated
  - Solid to form margarines, shortenings
  - Spreads for bread
  - Creaming for baked products
- BUT, trans ↑ LDL- and total cholesterol and TAG; ↓ HDL-cholesterol, ↑ heart disease

Processes to reduce trans FA by altering function/stability of oils

- Expeller press & physically refine oils to enhance stability; esp. health markets
  - Maillard browning products
  - Phospholipids (Frankel, 1998)
- Modify hydrogenation process to ↓ trans fatty acids
  - ↑ H_2 pressure, ↓ temp., ↑ catalyst conc.
- Interesterify oils to enhance solid functional properties

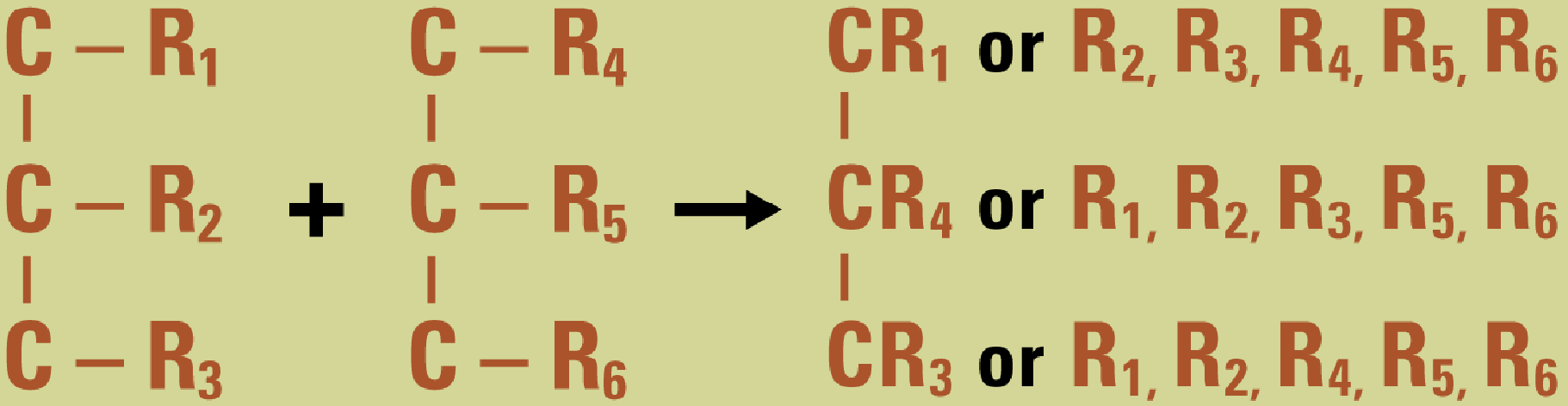
Interesterification

- Rearrange FA within the triacylglycerols (TAG) of a fat to alter melting and physical characteristics
- Chemical (random or directed) or enzymatic

Chemistry of Interesterification (INES)

R = fatty acid

= triacylglycerol



Oil 1

Oil 2

Interesterified Oil (theoretical)

Reasons to interesterify

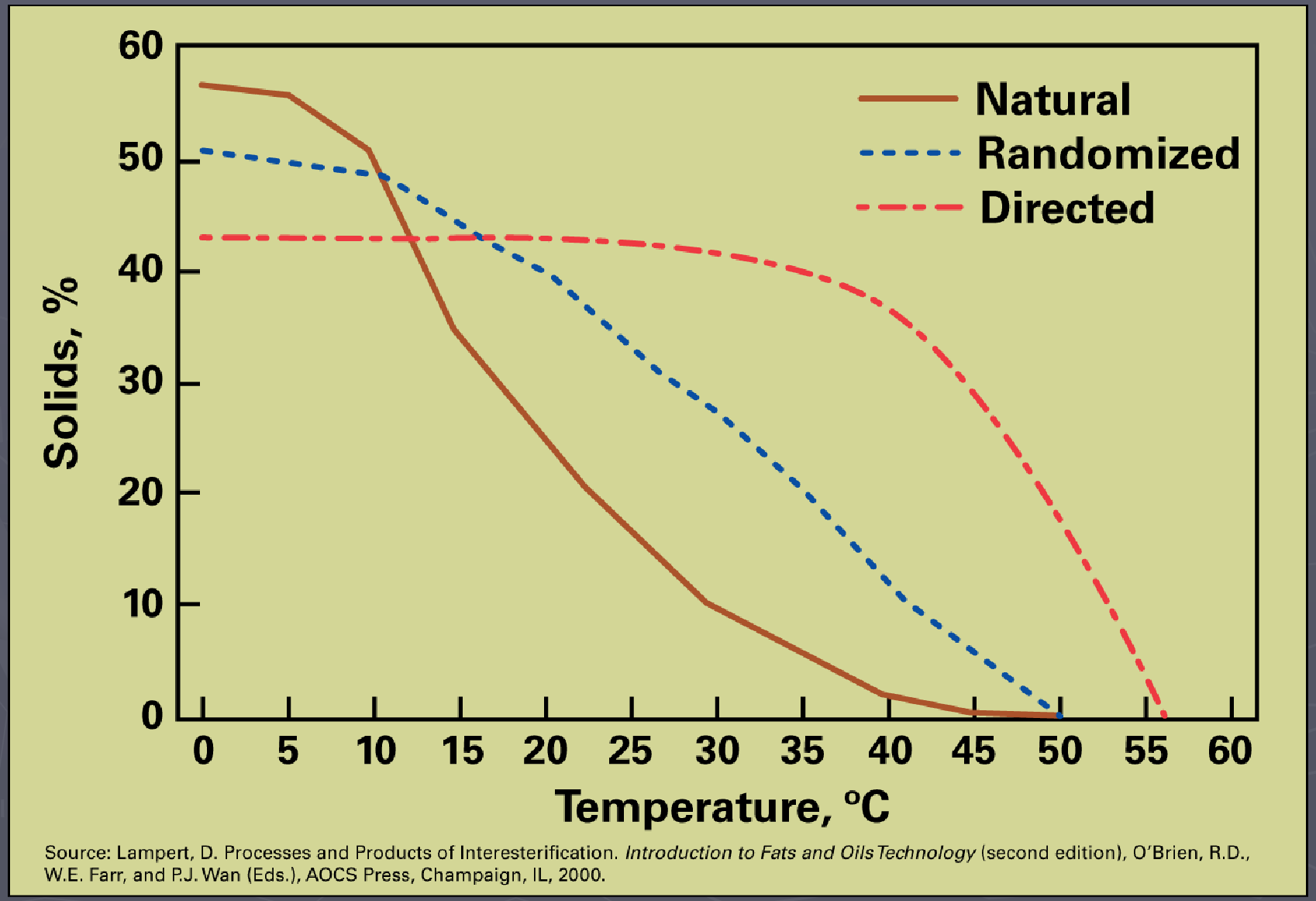
- Modify melting point of a TAG without changing FA composition
- Produce a solid without trans FA
- Modify solid fat index/content at various temperatures
- Modify/stabilize crystal structure of TAG molecules (β' crystals)

Effect of random INES on M.P.

	Melting point (°C)	
Fat	Before	After
Soybean oil	-17	5.5
Cottonseed oil	1.5	34
Coconut oil	26	28.5
Palm oil	40	47
Prime steam lard	43	43
Beef fat	46	44.5

Source: Sonntag, Bailey's Industrial Oil and Fat Products, 1982

Impact of INES on % solids



Source: Lampert, D. Processes and Products of Interesterification. *Introduction to Fats and Oils Technology* (second edition), O'Brien, R.D., W.E. Farr, and P.J. Wan (Eds.), AOCS Press, Champaign, IL, 2000.

trans FA method of measurement: Gas chromatography (GC), AOAC method 996.06 (2002)

- Mojonnier fat extraction
- Conversion to FA methyl esters
- Inject onto SP-2560 column, 100 m
- Time to run: ~ 1 hour
- Accuracy: to ~ 0.1g/serving
- Issues:
  - Sample prep and GC run times are lengthy

trans FA method of measurement: Attenuated Total Reflection-Fourier Transform Infrared Spectroscopy (ATR-FTIR), AOCS method Cd 14d-96 (2002-03)

- Mojonnier fat extraction
- No need to derivatize
- Load fat/oil into cell and read
- Time to read: ~ 1 minute
- Accuracy: ~ 0.5 g/serving (trans must be > 0.8 to 1% - depends on sample size)
- Issues:
  - fat cannot contain ≥ 5% conjugates
  - sample must be liquid while in cell
  - no distinction between different trans FA

Target for salad and cooking oils

- Needs:
  - Bland flavor
  - Light color
  - Good stability
  - Processing and packaging flexibility
- Choice: polyunsaturated and monounsaturated as possible (oil)

Target for frying oils

- Needs:
  - High stability
  - Extended fry life
  - Extended shelf life
  - Good deep-fried food flavor
- Choice: monounsaturated as possible, some PUFA (oil)

Target for margarines & shortenings

- Needs:
  - High stability
  - Extended shelf life
  - Good texture
  - Solid at room temperature
- Choice:
  some saturated FA for function; interesterified