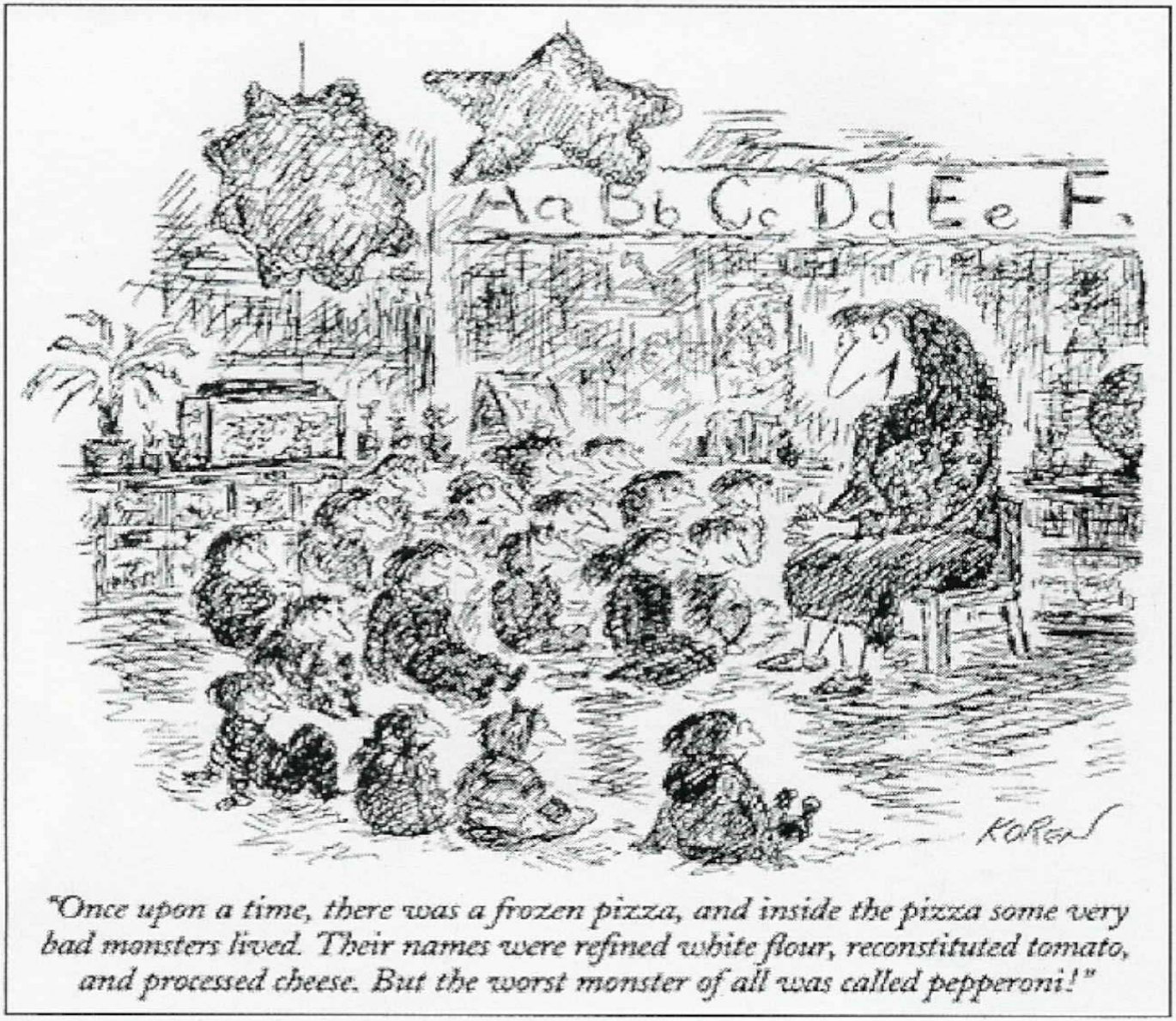
Lipids

- Structure – fat and fatty acid content
- Chemical reactions
- Nutritional properties



"Once upon a time, there was a frozen pizza, and inside the pizza some very bad monsters lived. Their names were refined white flour, reconstituted tomato, and processed cheese. But the worst monster of all was called pepperoni!"

URL: http://www.consumerfreedom.com/cartoons.cfm/page/7

Fat content of some foods

- Cod 0.4
- Asparagus 0.25%
- Rice 1.4
- Milk 3.5
- Chicken 7
- Beef 10-30
- Soybean 17
- Sunflower 28
- Cheese 35
- Butter 80

Types of lipid molecules

- Fatty acids
- Diglycerides
- Triglycerides
- Phospholipids
- Cholesterols and other sterols

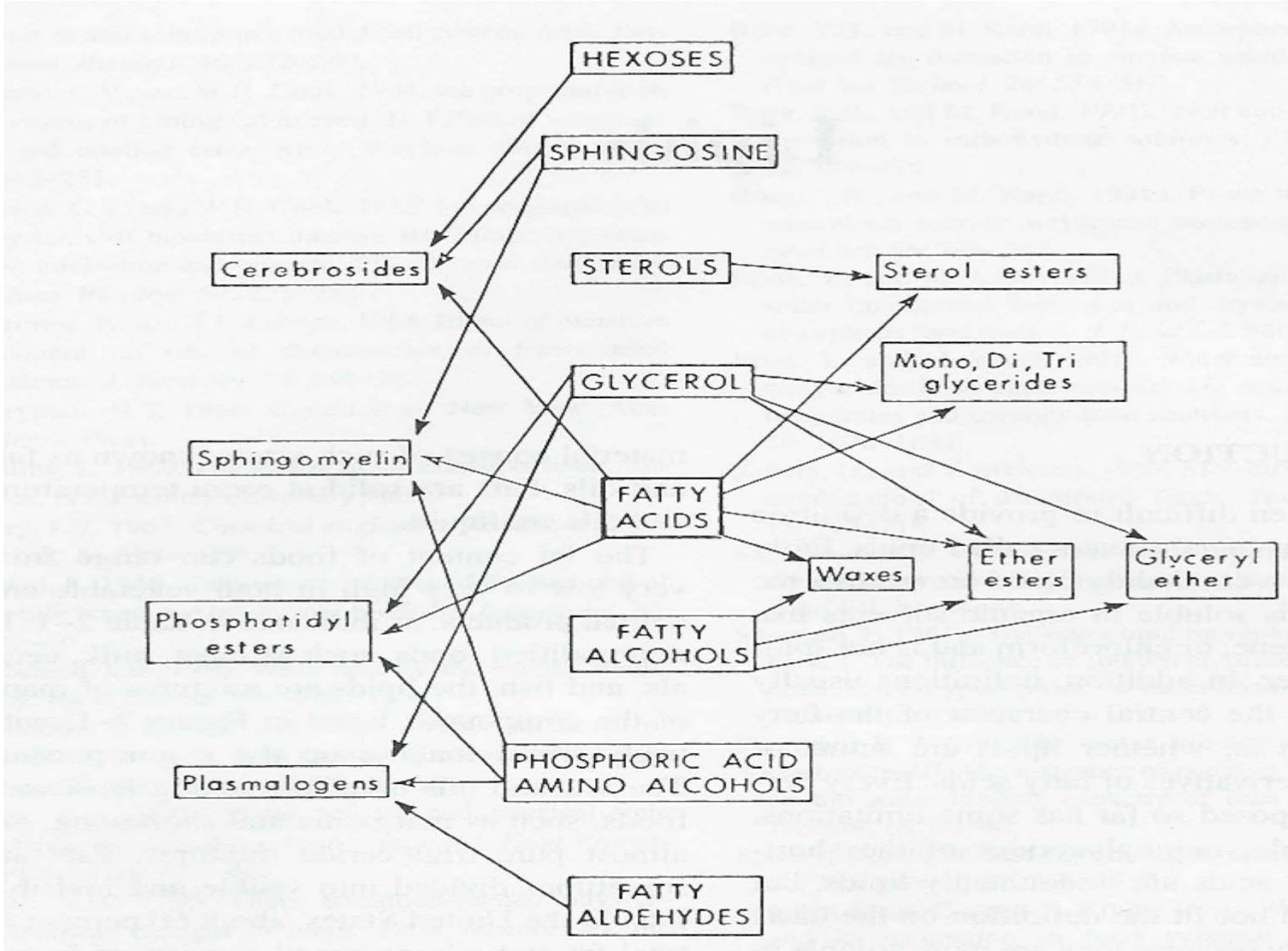
Table 12.1 Fat Content in Selected Foods (1 Tablespoon)[a]

Food	Total Fat (g)	Saturated Fat (g)	*Trans* Fat (g)	Sat. + Trans (g)
Butter	10.8	7.2	0.3	7.5
Margarine				
stick	11	2.1	2.8	4.9
spread	9.7	1.8	2.7	4.5
tub	6.7	1.2	0.6	1.8
bottle	0.4	0.1	0	0.1
Shortening	13	3.4	4.2	7.6
French fries[b]	26.9	6.7	7.8	14.5
Potato chips[c]	11.2	1.9	3.2	5.1
Doughnut	18.2	4.7	5	9.7

[a] Values from USDA National Nutrient Database for Standard Reference, Releases 15 and 16, 1995 USDA Composition Data, and FDA Table of *trans* Values.

[b] Medium size serving at a fast food restaurant.

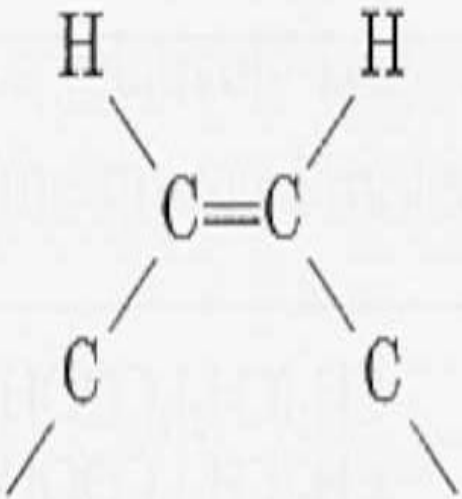
[c] Small bag


HEXOSES
SPHINGOSINE
Cerebrosides
STEROLS
Sterol esters
Mono, Di, Tri glycerides
GLYCEROL
Sphingomyelin
FATTY ACIDS
Ether esters
Glyceryl ether
Waxes
Phosphatidyl esters
FATTY ALCOHOLS
PHOSPHORIC ACID AMINO ALCOHOLS
Plasmalogens
FATTY ALDEHYDES

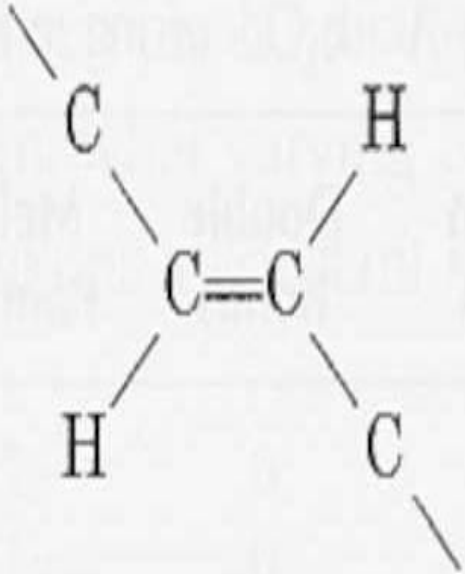

$117 BILLION FOR OBESITY COSTS
YOU KNOW, WE COULD GET TO THE $117 BILLION IF WE COUNTED SOME OF THIS STUFF TWICE.
BIG PHARMA
BIG PHARMA


OBESITY EPIDEMIC... OBESITY EPIDEMIC...
BIG PHARMACEUTI
COMPANIES
2005
CENTER FOR
CONSUMER
FREEDOM

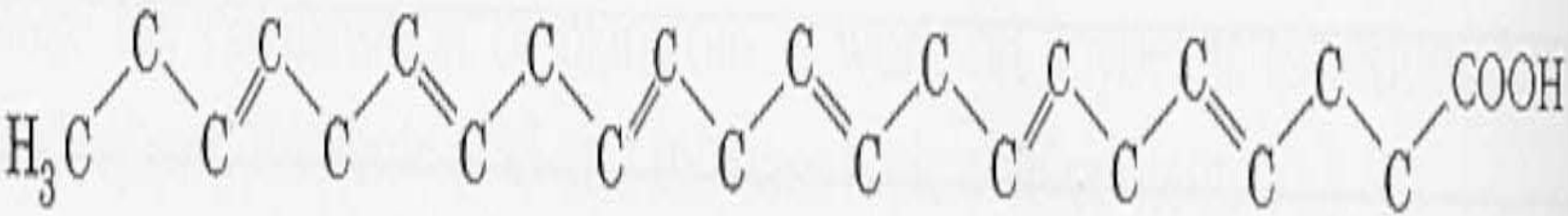

No Child with A fat BehiNd
THE OBESITY HYPE/BMI REPORT CARDS ARE GETTING A BIT RIDICULOUS...



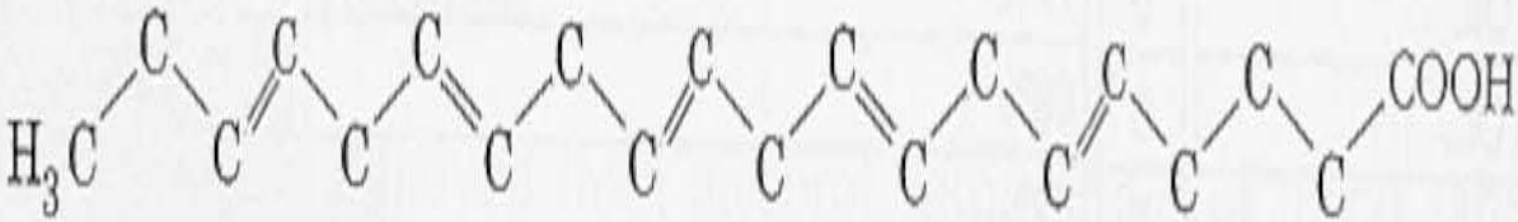
cis
(oleic m.p. = 14°C)



trans
(elaidic m.p. = 43.7°C)



Docosahexanoic Acid (DHA)



Eicosapentanoic Acid (EPA)

Systematic Name	*Common Name*	*Formula*	*Shorthand Description*
Dec-9-enoic		$CH_2{=}CH{\cdot}(CH_2)_7{\cdot}COOH$	10:1
Dodec-9-enoic		$CH_3{\cdot}CH_2{\cdot}CH{=}CH{\cdot}(CH_2)_7{\cdot}COOH$	12:1
Tetradec-9-enoic	Myristoleic	$CH_3{\cdot}(CH_2)_3{\cdot}CH{=}CH{\cdot}(CH_2)_7{\cdot}COOH$	14:1
Hexadec-9-enoic	Palmitoleic	$CH_3{\cdot}(CH_2)_5{\cdot}CH{=}CH{\cdot}(CH_2)_7{\cdot}COOH$	16:1
Octadec-6-enoic	Petroselinic	$CH_3{\cdot}(CH_2)_{10}{\cdot}CH{=}CH{\cdot}(CH_2)_4{\cdot}COOH$	18:1
Octadec-9-enoic	Oleic	$CH_3{\cdot}(CH_2)_7{\cdot}CH{=}CH{\cdot}(CH_2)_7{\cdot}COOH$	18:1
Octadec-11-enoic	Vaccenic	$CH_3{\cdot}(CH_2)_5{\cdot}CH{=}CH{\cdot}(CH_2)_9{\cdot}COOH$	18:1
Octadeca-9:12-dienoic	Linoleic	$CH_3{\cdot}(CH_2)_4{\cdot}(CH{=}CH{\cdot}CH_2)_2{\cdot}(CH_2)_6{\cdot}COOH$	18:2ω6
Octadeca-9:12:15-trienoic	Linolenic	$CH_3{\cdot}CH_2{\cdot}(CH{=}CH{\cdot}CH_2)_3{\cdot}(CH_2)_6{\cdot}COOH$	18:3ω3
Octadeca-6:9:12-trienoic	γ-Linolenic	$CH_3{\cdot}(CH_2)_4{\cdot}(CH{=}CH{\cdot}CH_2)_3{\cdot}(CH_2)_3{\cdot}COOH$	18:3ω6
Octadeca-9:11:13-trienoic	Elaeostearic	$CH_3{\cdot}(CH_2)_3{\cdot}(CH{=}CH)_3{\cdot}(CH_2)_7{\cdot}COOH$	20:3
Eicos-9-enoic	Gadoleic	$CH_3{\cdot}(CH_2)_9{\cdot}CH{=}CH{\cdot}(CH_2)_7{\cdot}COOH$	20:1
Eicosa-5:8:11:14-tetraenoic	Arachidonic	$CH_3{\cdot}(CH_2)_4{\cdot}(CH{=}CH{\cdot}CH_2)_4{\cdot}(CH_2)_2{\cdot}COOH$	20:4ω6
Eicosa-5:8:11:14:17-pentaenoic acid	EPA	$CH_3{\cdot}CH_2{\cdot}(CH{=}CH{\cdot}CH_2)_5{\cdot}(CH_2)_2{\cdot}COOH$	20:5ω3
Docos-13-enoic	Erucic	$CH_3{\cdot}(CH_2)_7{\cdot}CH{=}CH{\cdot}(CH_2)_{11}{\cdot}COOH$	22:1
Docosa-4:7:10:13:16:19-hexaenoic acid	DHA	$CH_3{\cdot}CH_2(CH{=}CH{\cdot}CH_2)_6{\cdot}(CH_2){\cdot}COOH$	22:6ω3

Table 11.1 Selected Fatty Acids Occurring in Foods

Common Name	Carbon Atoms	Double Bonds	Melting Pont (°C)	Structure
Butyric	4	0	−7.9	$CH_3(CH_2)_2COOH$
Caproic	6	0	−1	$CH_3(CH_2)_4COOH$
Caprylic	8	0	16	$CH_3(CH_2)_6COOH$
Capric	10	0	31.5	$CH_3(CH_2)_8COOH$
Lauric	12	0	48	$CH_3(CH_2)_{10}COOH$
Myristic	14	0	57–58	$CH_3(CH_2)_{12}COOH$
Palmitic	16	0	64	$CH_3(CH_2)_{14}COOH$
Palmitoleic[a]	16	1		$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$
Stearic	18	0	69.6	$CH_3(CH_2)_{16}COOH$
Oleic[a]	18	1[b]	14	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
Elaidic[a]	18	1[c]	43.7	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
Linoleic[a]	18	2	−5.0	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$
Linolenic[a]	18	3	−11.0	$CH_3(CH_2CH{=}CH)_3(CH_2)_7COOH$
Arachidic	20	0	77	$CH_3(CH_2)_{18}COOH$
Arachidonic[a,d]	20	4	50	$CH_3(CH_2)^4(CH{=}CHCH_2)_4(CH_2)_2COOH$

[a]Unsaturated fatty acid.
[b]Double bond is *cis* configuration.
[c]Double bond is *trans* configuration.
[d]The systematic name is 5, 8,11,14-eicosatetraenoic acid.
Source: Adapted from *Van Nostrand's Scientific Encyclopedia*. 5th ed. Considine, D. M., ed. Van Nostrand Reinhold: New York, 1976.

Table 2–11 Component Fatty Acids of Some Vegetable Oils

	Fatty Acid Wt%					
Oil	*16:0*	*18:0*	*18:1*	*18:2*	*18:3*	*Total C18*
Canola	4	2	56	26	10	96
Cottonseed	27	2	18	51	Trace	73
Peanut*	13	3	38	41	Trace	83
Olive	10	2	78	7	—	90
Rice bran	16	2	42	37	1	84
Soybean	11	4	22	53	8	89
Sunflower	5	5	20	69	—	95
Sunflower high oleic	4	5	81	8	—	96
Palm	44	4	39	11	—	54
Cocoa butter	26	34	35	3	—	74

*Peanut oil also contains about 3% of 22:0 and 1% of 22:1.

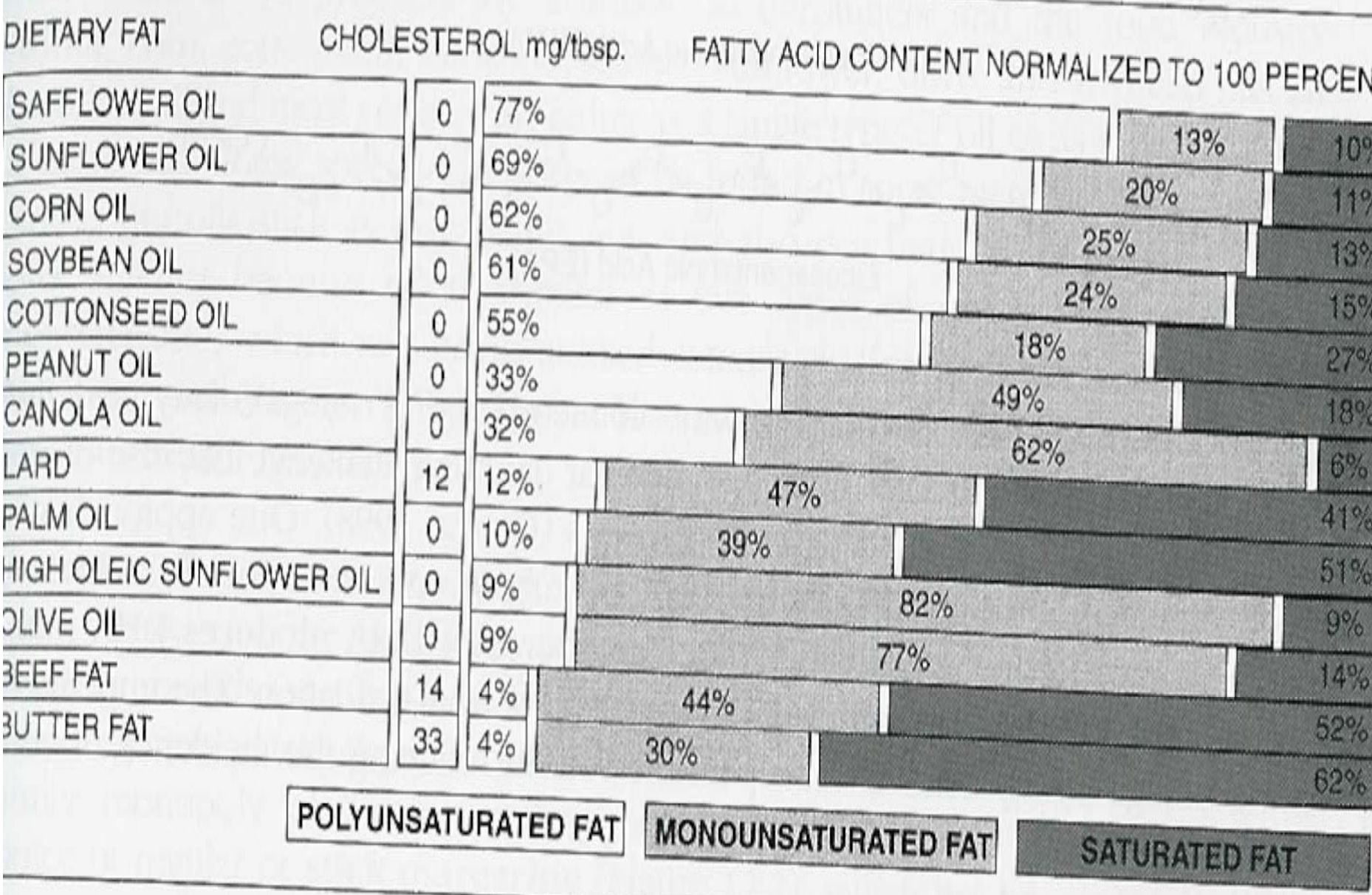
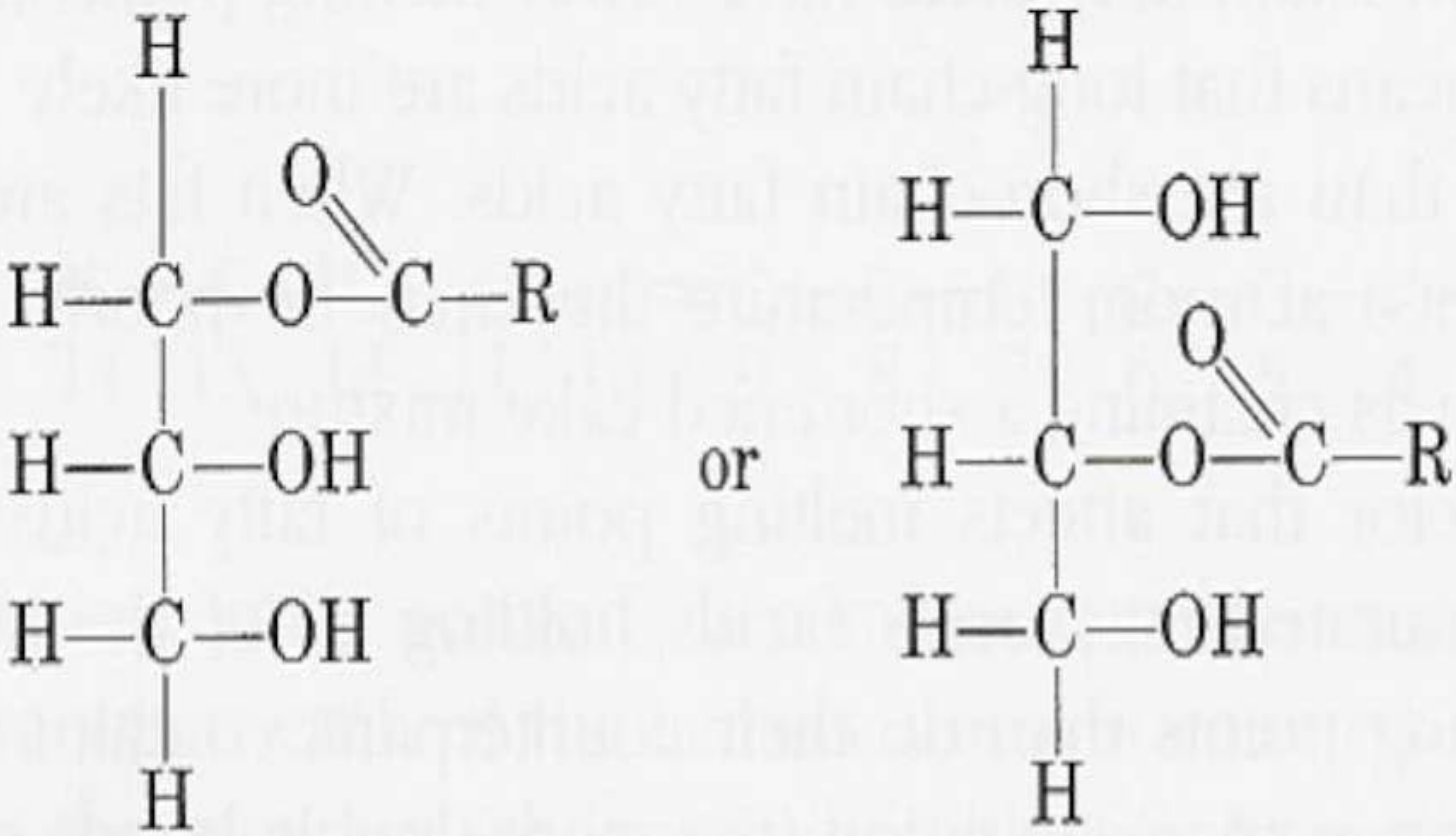

DIETARY FAT
CHOLESTEROL mg/tbsp.
FATTY ACID CONTENT NORMALIZED TO 100 PERCEN
SAFFLOWER OIL 0 77% 13% 10%
SUNFLOWER OIL 0 69% 20% 11%
CORN OIL 0 62% 25% 13%
SOYBEAN OIL 0 61% 24% 15%
COTTONSEED OIL 0 55% 18% 27%
PEANUT OIL 0 33% 49% 18%
CANOLA OIL 0 32% 62% 6%
LARD 12 12% 47% 41%
PALM OIL 0 10% 39% 51%
HIGH OLEIC SUNFLOWER OIL 0 9% 82% 9%
OLIVE OIL 0 9% 77% 14%
BEEF FAT 14 4% 44% 52%
BUTTER FAT 33 4% 30% 62%
POLYUNSATURATED FAT
MONOUNSATURATED FAT
SATURATED FAT

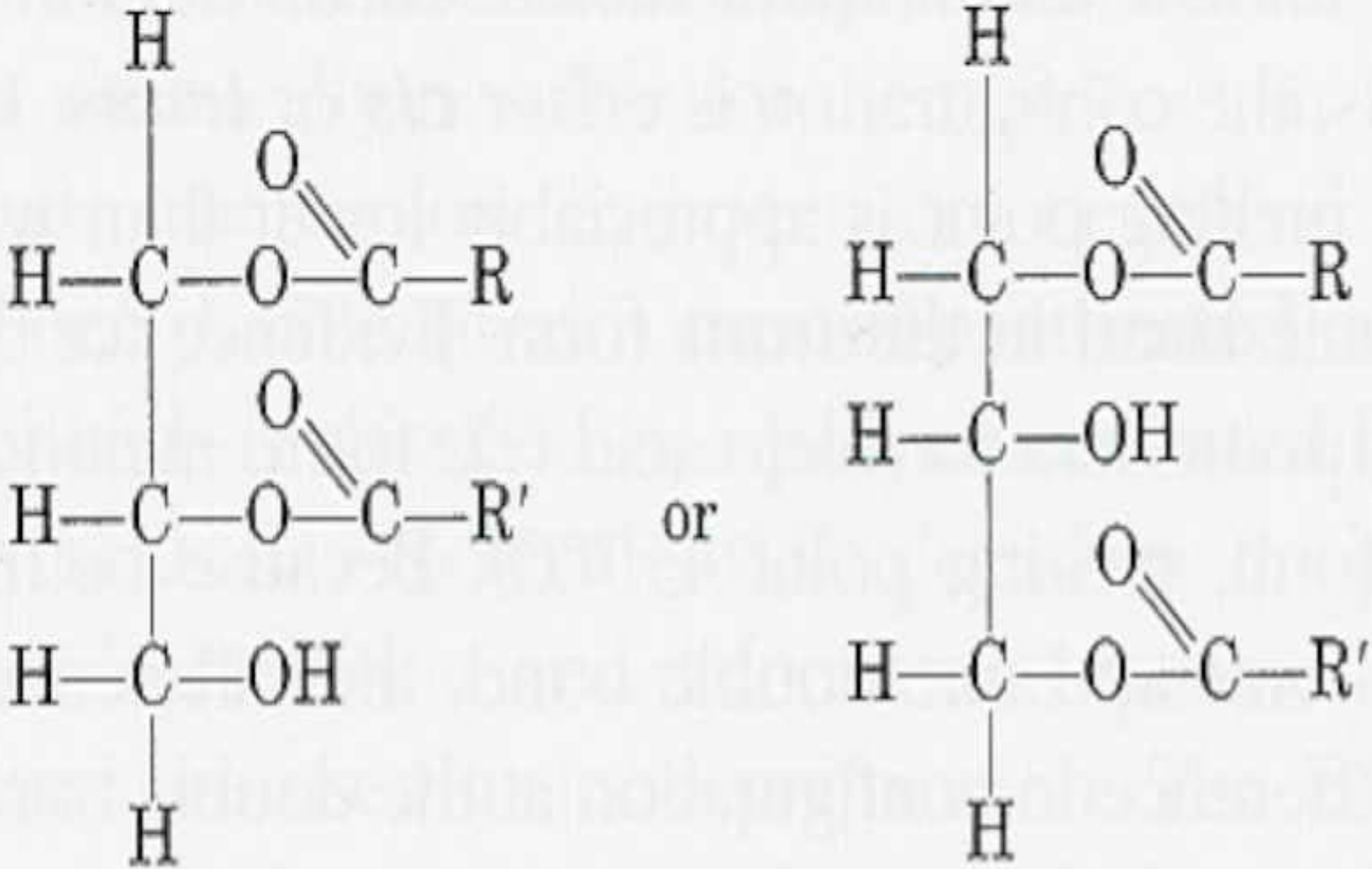
Table 2–5 The Component Fatty Acids of Some Milk Fats in Mole %

Fatty Acid	*Cow*	*Goat*	*Sheep*
4:0	9.5	7.5	7.5
6:0	4.1	4.7	5.3
8:0	0.8	4.3	3.5
10:0	3.2	12.8	6.4
Total short chain	17.6	29.3	22.7
12:0	2.9	6.6	4.5
14:0	11.5	11.8	9.9
16:0	26.7	24.1	21.6
18:0	7.6	4.7	10.3
20:0	1.8	0.4	0.8
10–12 unsaturated	1.1	1.4	1.0
16:1	4.3	2.2	2.0
18:1	22.4	16.5	21.6
18:2	3.1	2.8	4.3
20–22 unsaturated	1.0	0.2	1.3

Source: From T.P. Hilditch and P.N. Williams, *The Chemical Constitution of Natural Fats*, 4th ed., 1964, John Wiley & Sons.



forms of monoglycerides



forms of diglycerides

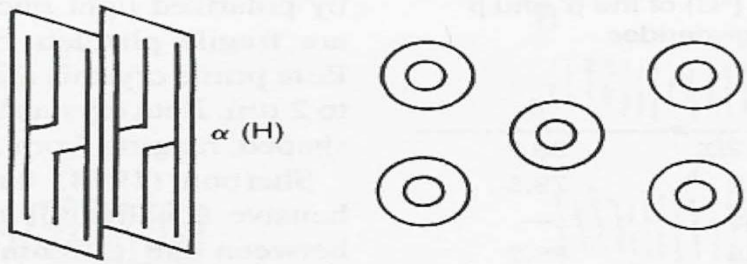
Table 2–41 HLB Values of Some Commercial Nonionic Emulsifiers

Trade Name	*Chemical Designation*	*HLB*
Span 85	Sorbitan trioleate	1.8
Span 65	Sorbitan tristearate	2.1
Atmos 150	Mono- and diglycerides from the glycerolysis of edible fats	3.2
Atmul 500	Mono- and diglycerides from the glycerolysis of edible fats	3.5
Atmul 84	Glycerol monostearate	3.8
Span 80	Sorbitan monooleate	4.3
Span 60	Sorbitan monostearate	4.7
Span 40	Sorbitan monopalmitate	6.7
Span 20	Sorbitan monolaurate	8.6
Tween 61	Polyoxyethylene sorbitan monostearate	9.6
Tween 81	Polyoxyethylene sorbitan monooleate	10.0
Tween 85	Polyoxyethylene sorbitan trioleate	11.0
Arlacel 165	Glycerol monostearate (acid stable, self-emulsifying)	11.0
Myrj 45	Polyoxyethylene monostearate	11.1
Atlas G-2127	Polyoxyethylene monolaurate	12.8
Myrj 49	Polyoxyethylene monostearate	15.0
Myrj 51	Polyoxyethylene monostearate	16.0

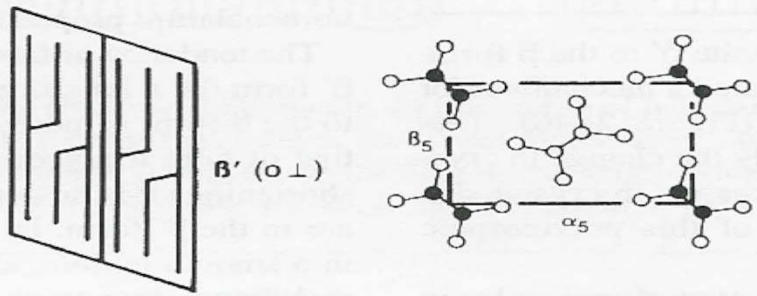
Source: From W.C. Griffin, Emulsions, in *Kirk-Othmer Encyclopedia of Chemical Technology*, 2nd ed., Vol. 8, pp. 117–154, 1965, John Wiley & Sons.

Triglycerides

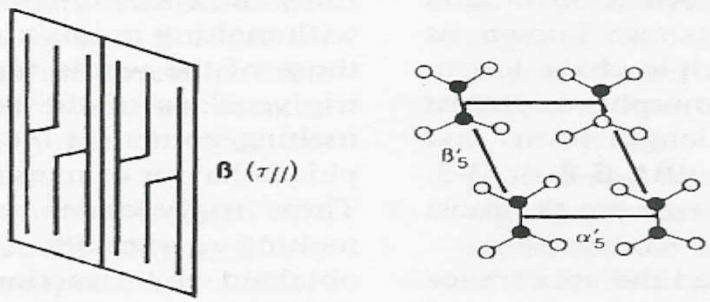
- ✓ Most common storage form of fat in animals and plants
- ✓ Most common form in foods
- ✓ α and β configurations
  - ✓ PUFA tend to be at position 2
- ✓ Crystal formation – texture
  - ✓ Fatty acid composition, triglyceride structure, T
- ✓ Hydrogenation
- ✓ Oxidation



a: **α**: unstable, lifetime < 60 s.
present during process



b: **ß′**: metastable (>60 s --> years)
present in products



c: **ß**: stable

Representation of the Packing of Triacylglycerols in the Three Main Polymorphic Forms

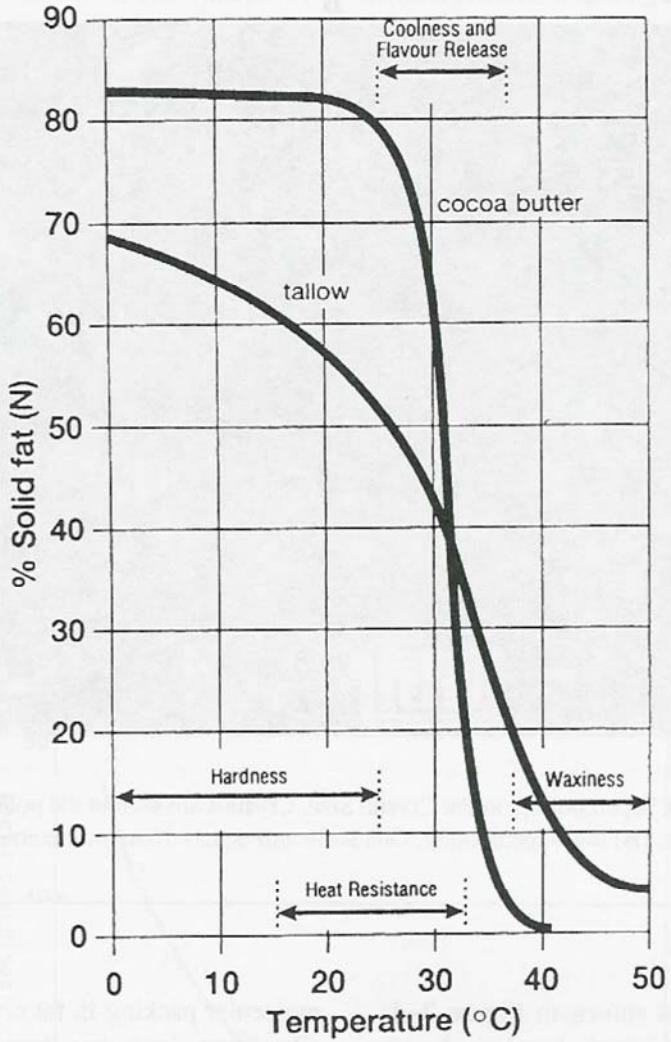


Figure 2–39 Physical Properties of Tallow and Cocoa Butter as Influenced by Solid Fat Profile. *Source:* Reprinted with permission from U. Bracco, Effect of Triglyceride Structure on Fat Absorption, *American Journal of Clinical Nutrition,* Vol. 60, (Suppl.) p. 1008S, © 1994, American Society for Clinical Nutrition.

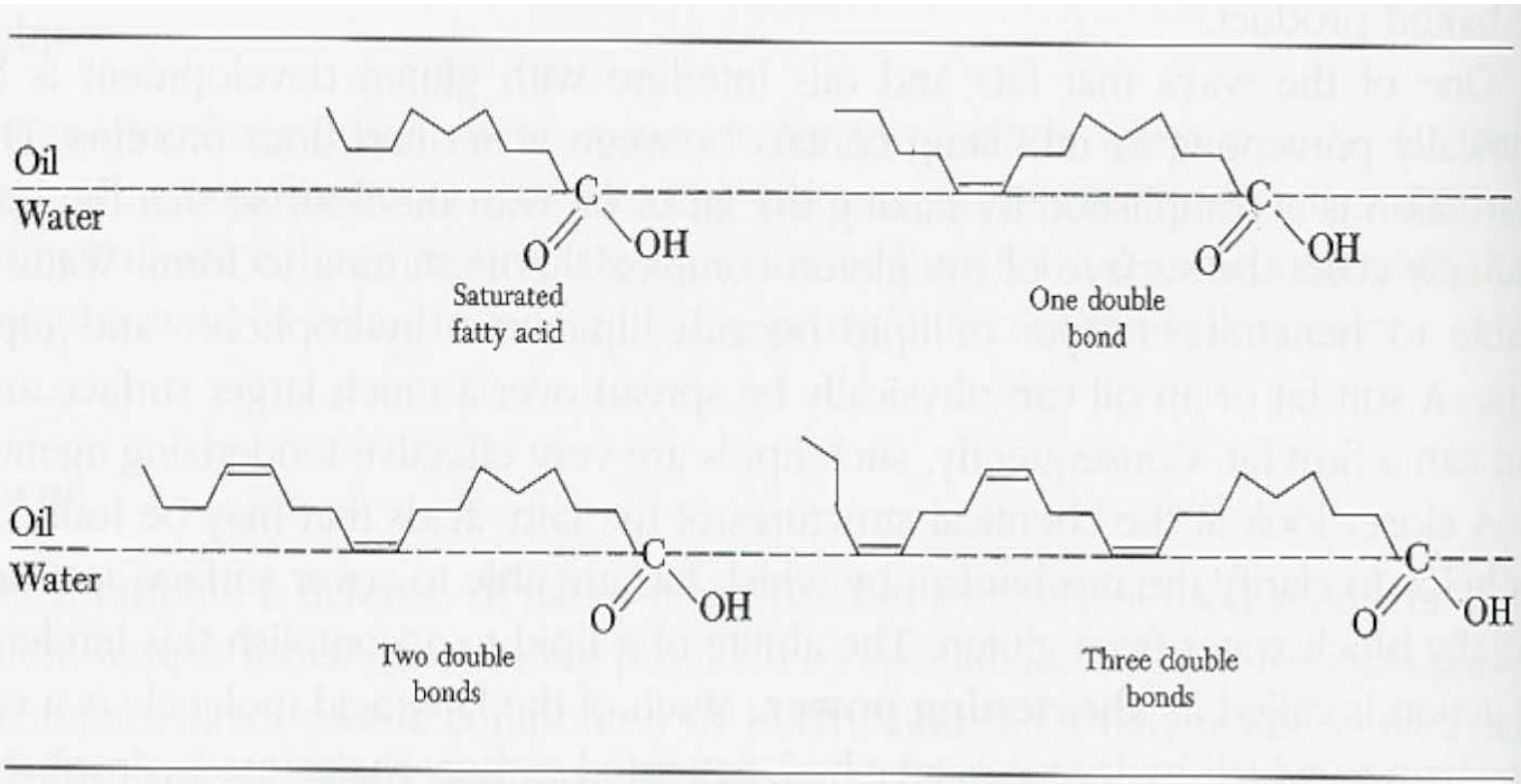


Figure 12.4 Schematics illustrating the shortening power of fatty acids with different numbers of double bonds. Note that fatty acids with one or two double bonds are more effective in covering surface area than is a saturated fatty acid, but far more area is covered by fatty acids with three double bonds.

Hydrogenation

- Provide liquid oil with ‘solid fat’ properties
- Convert cis double bonds to trans double bonds and to single (saturated bonds)
- Catalyst, heat

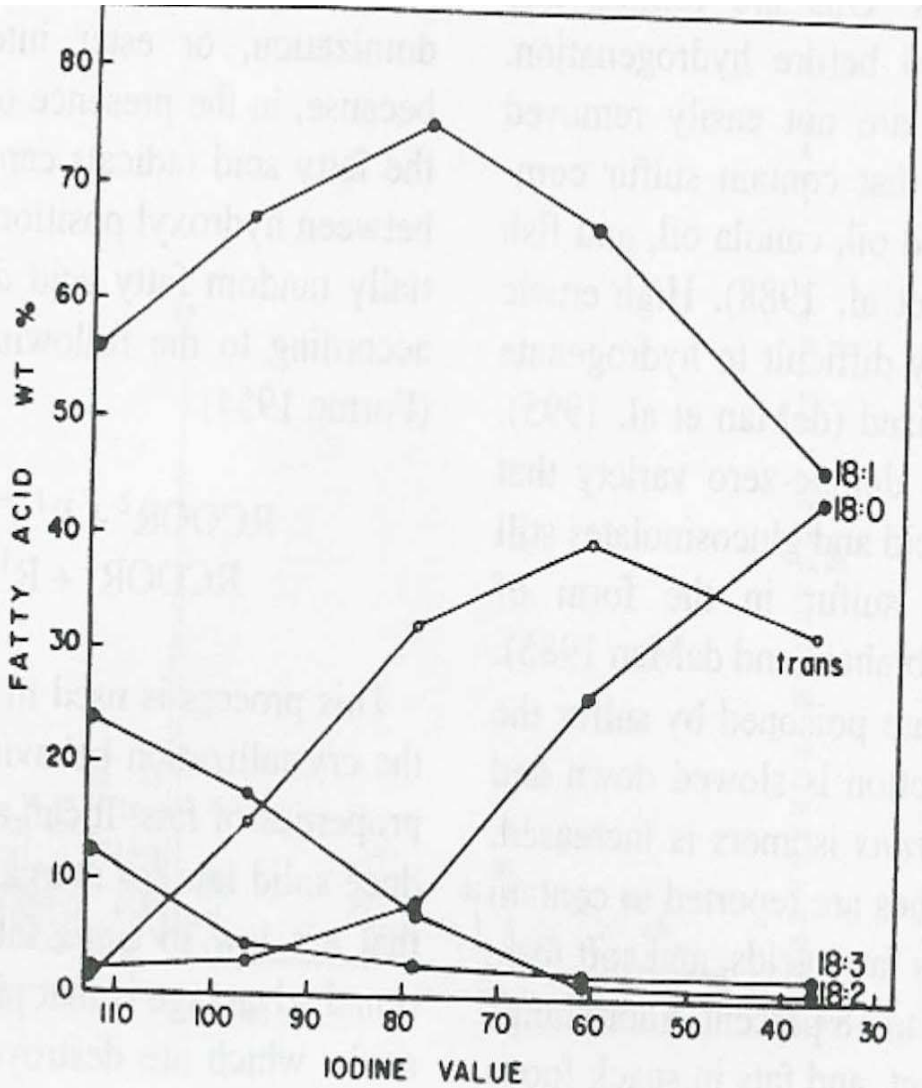


Figure 2–31 Change in Fatty Acid Composition During Hydrogenation of Canola Oil

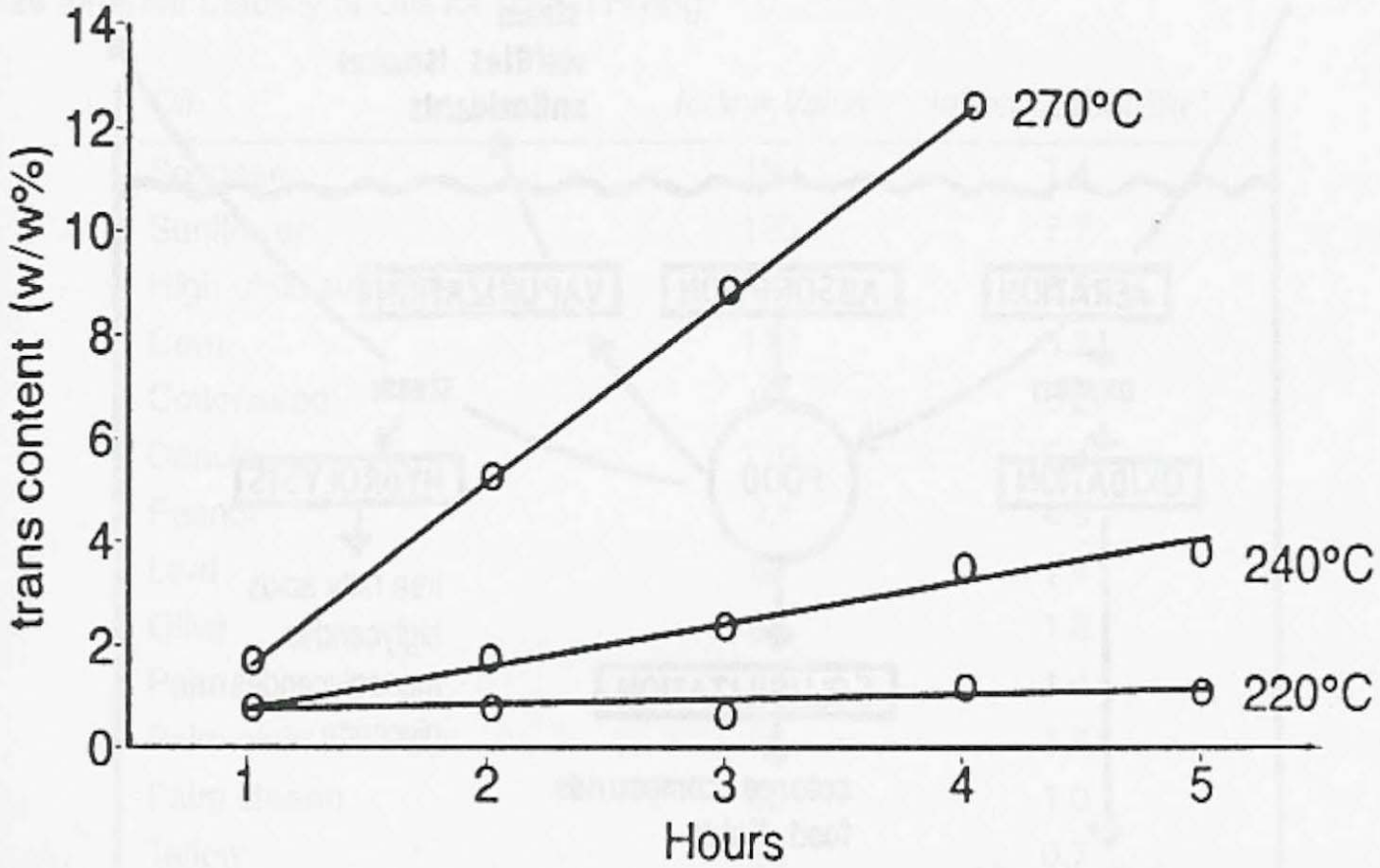


Figure 2–22 *Trans* Isomer Formation in Sunflower Oil as a Function of Deodorization Temperature. *Source:* Reprinted from R.G. Ackman, Animal and Marine Lipids, in *Improved and Technological Advances in Alternative Sources of Lipids*, B. Kamel and Y. Kakuda, eds., p. 301, 1994, Aspen Publishers, Inc.

Deleterious changes to lipid

- Hydrolysis (frying)
- Oxidation (frying, dehydration, storage, freezing)
- Loss of polyunsaturated fatty acids
- Flavor and color changes
- Free radicals- can cause loss of vitamins and essential amino acids

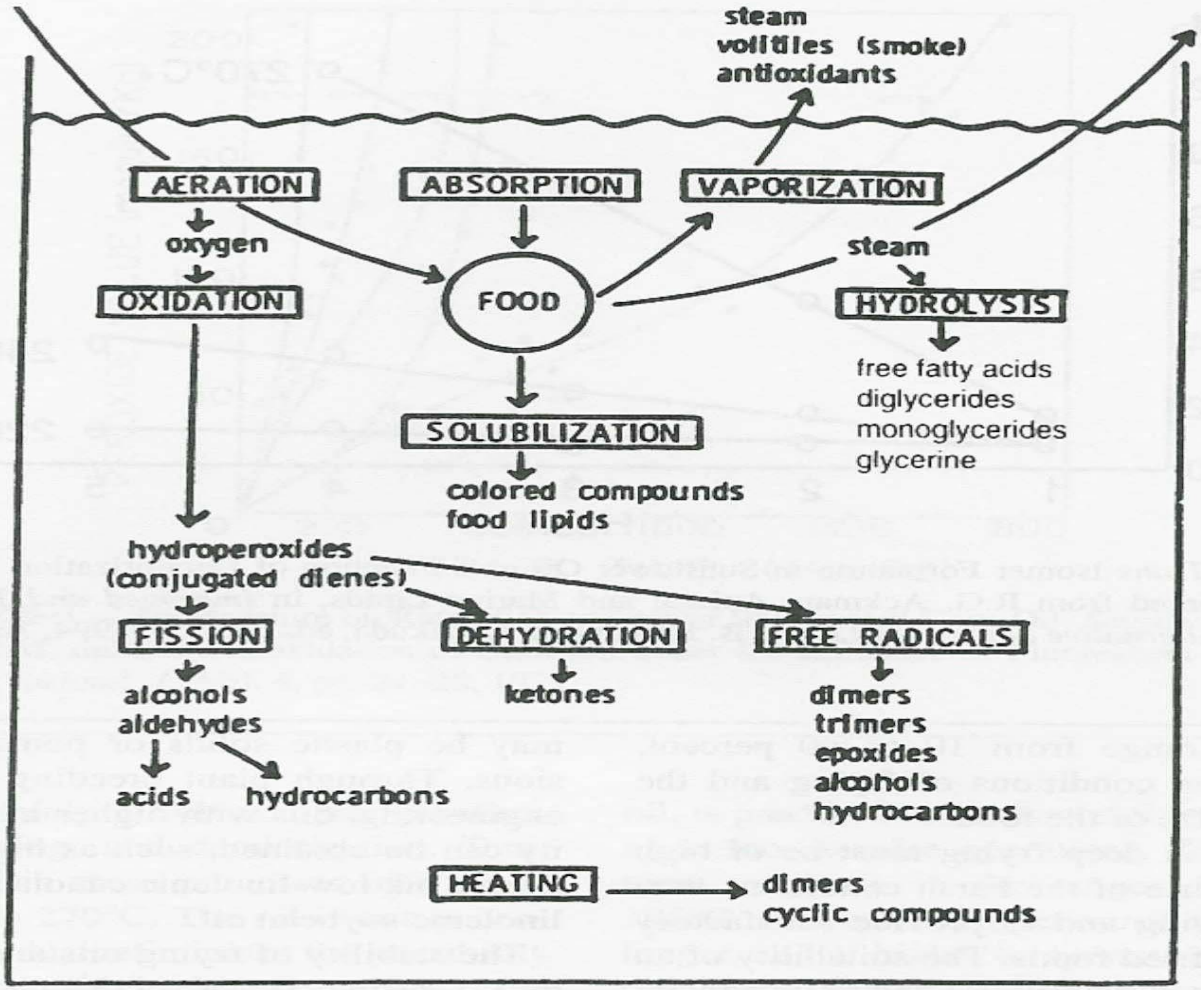


Figure 2–23 Summary of Chemical Reactions Occurring During Deep Frying. *Source:* Reprinted with permission from F.T. Orthoefer, S. Gurkin, and K. Lui, Dynamics of Frying in Deep Frying, in *Chemistry, Nutrition and Practical Applications*, E.G. Perkins and M.D. Erickson, eds., p. 224. © 1996, AOCS Press.

Peroxide formation (a free radical reaction)

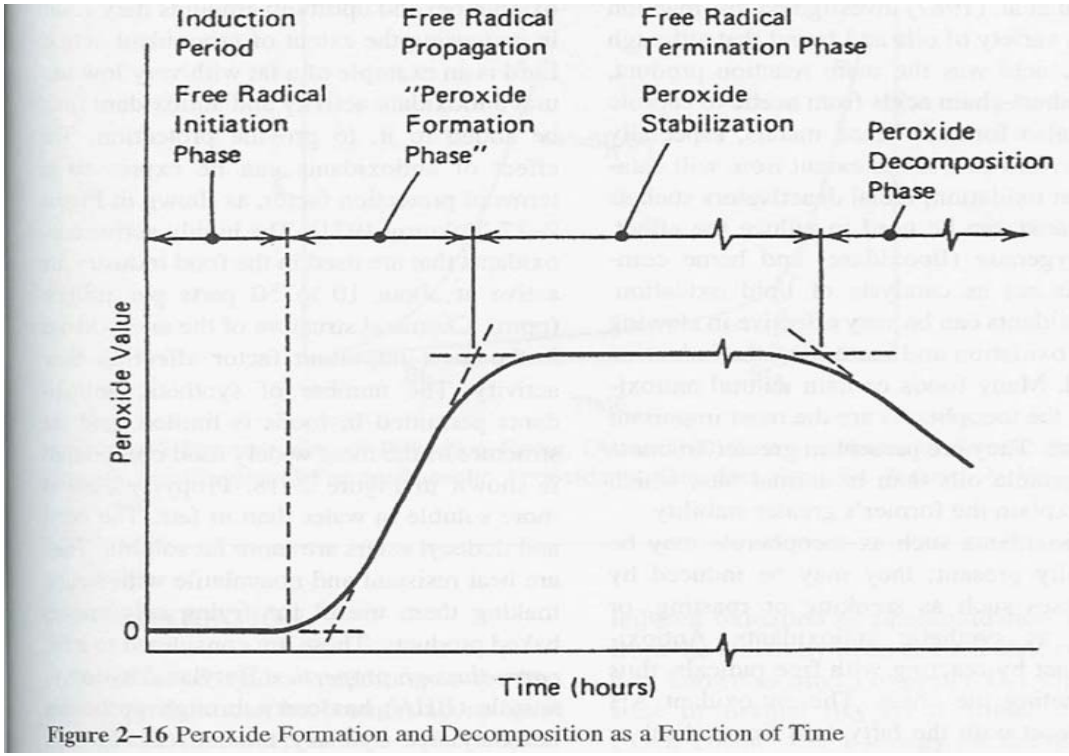


Figure 2–16 Peroxide Formation and Decomposition as a Function of Time

Antioxidants- ‘protect’ fat from oxidation. Are preferentially oxidize (sacrificed) to protect fat

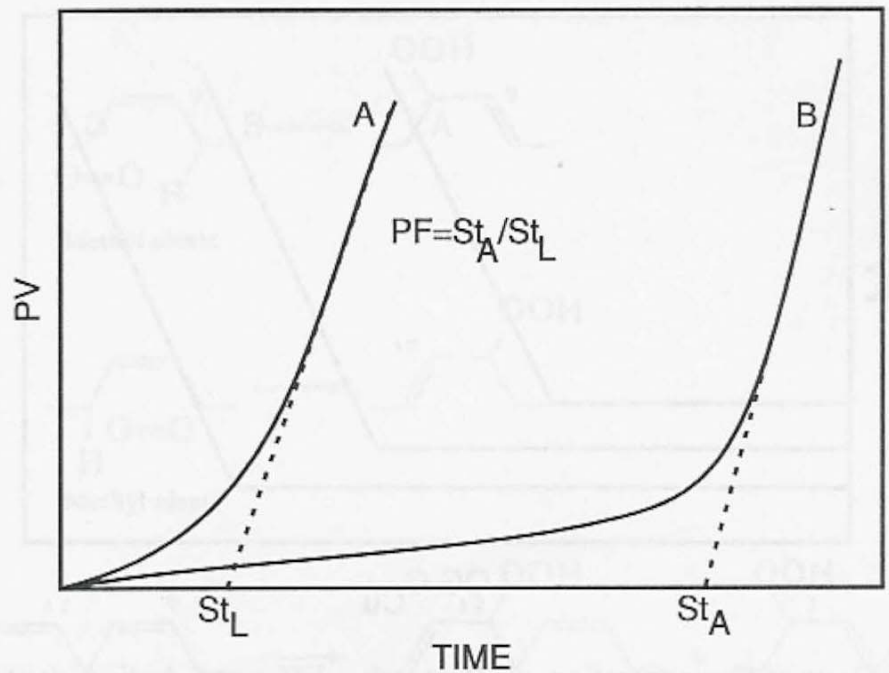


Figure 2–17 Determination of Protection Factor. (A) lard, (B) lard + antioxidant. *Source:* From J. Pokorny, Stabilization of Fats by Phenolic Antioxidants, *Can. Inst. Food Sci. Technol. J.*, Vol. 4, pp. 68–74, 1971.

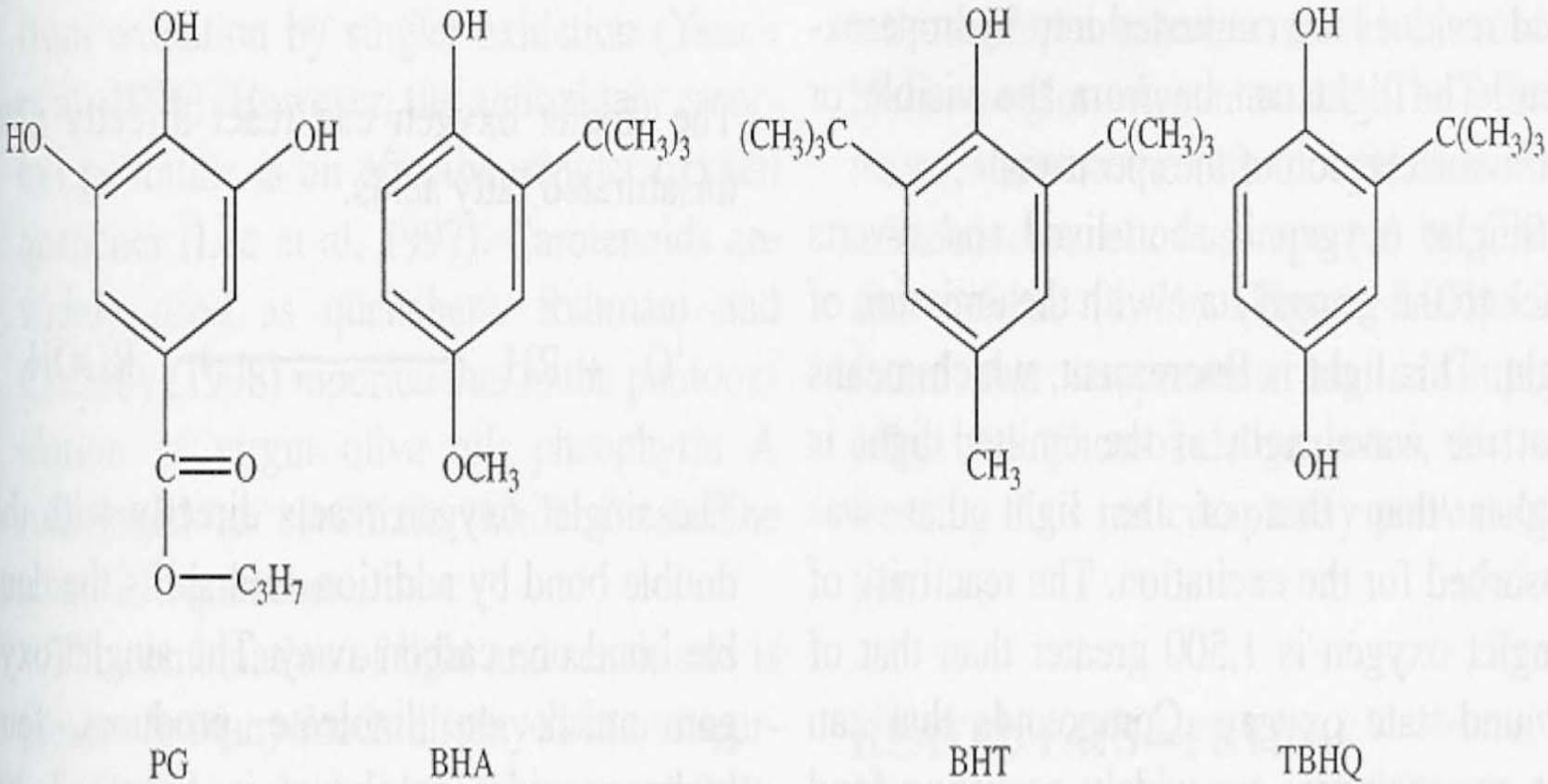
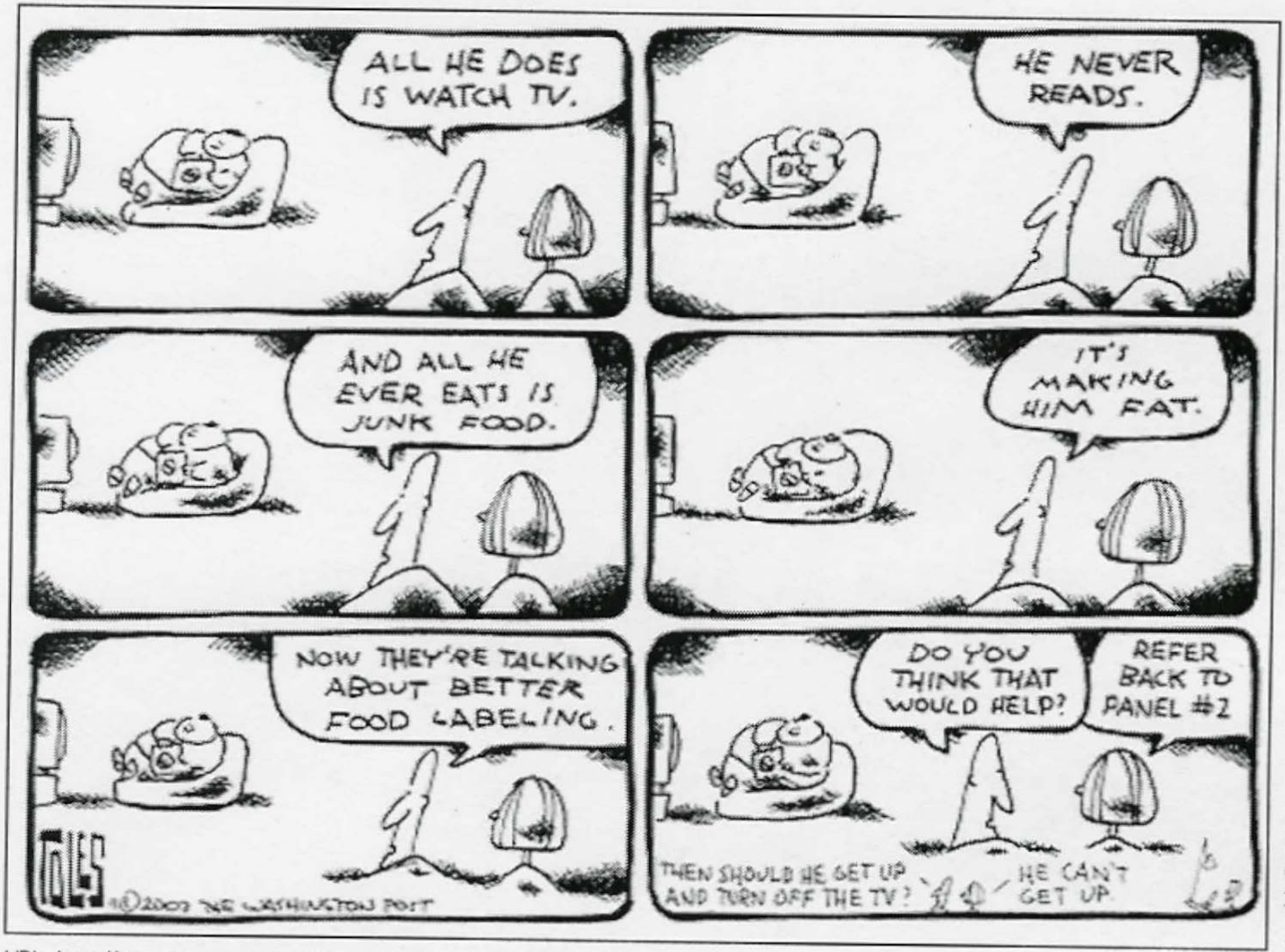


Figure 2–18 Structure of Propyl Gallate (PG), Butylated Hydroxyanisole (BHA), Butylated Hydroxy Toluene (BHT), and Tert-Butyl Hydroquinone (TBHQ)

Table 11.2 Some Chemical and Natural Antioxidants and Their Uses

Antioxidant	Action/Characteristics	Applications
EDTA[a]	Slow oxidation by metals	Vegetable oil-containing foods
Citric acid	Chelate metals in meat	Meats
Phosphates	Complexes with metal ions	Meats
BHA[b]	Survives baking and frying	Foods containing animal fats
BHT[c]	Survives baking and frying	Foods containing animal fats
TBHQ[d]	Survives frying temperatures	Vegetable oil-containing foods
Propyl gallate	Heat sensitive	Vegetable oil-containing foods
Tocopherols	Can add with vitamin C, etc.	Foods containing animal fats
Rosemary	Delay free radical formation	Meats, irradiated ground beef
Thyme, oregano	Avoid warmed over-flavor	Comminuted poultry, meat, fish
Dried plums	Retard lipid oxidation	Sausage and other ground meat
Honey	Darker is more effective	Ground turkey

[a]Ethylenediaminetetraacetic acid
[b]Butylated hydroxyanisole
[c]Butylated hydroxytoluene
[d]Tertiary-butylhydroquinone



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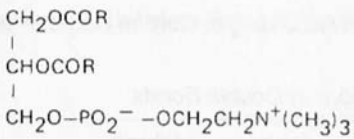
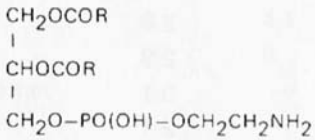
Other lipid components

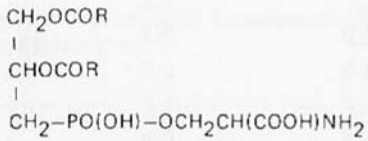
- Phospholipids
- Sterols



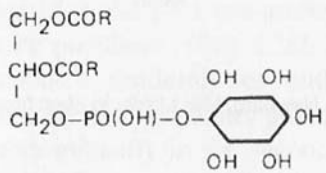
Phosphatidylcholine
(lecithin)



Phosphatidylethanolamine
(cephalin)



Phosphatidylserine



Phosphoinositides

Sterols

- Cholesterol – 240 high (37 million Americans), 220-239 borderline (105 million Americans) .
- HDL- lipoprotein carries CHL to liver
- LDL- lipoprotein carries CHL in blood stream

Food components and CHL levels

- Soluble fiber (oat bran – 5.5% beta-glucan) may lower LDL – traps dietary CHL during passage through GI tract (increase viscosity in upper GIO and reduce reabsoption of bile acids making less available for CHL synthesis.
- High levels of galactomannans ->short chain fatty acids that displace serum CHL in liver
- Glycemic control

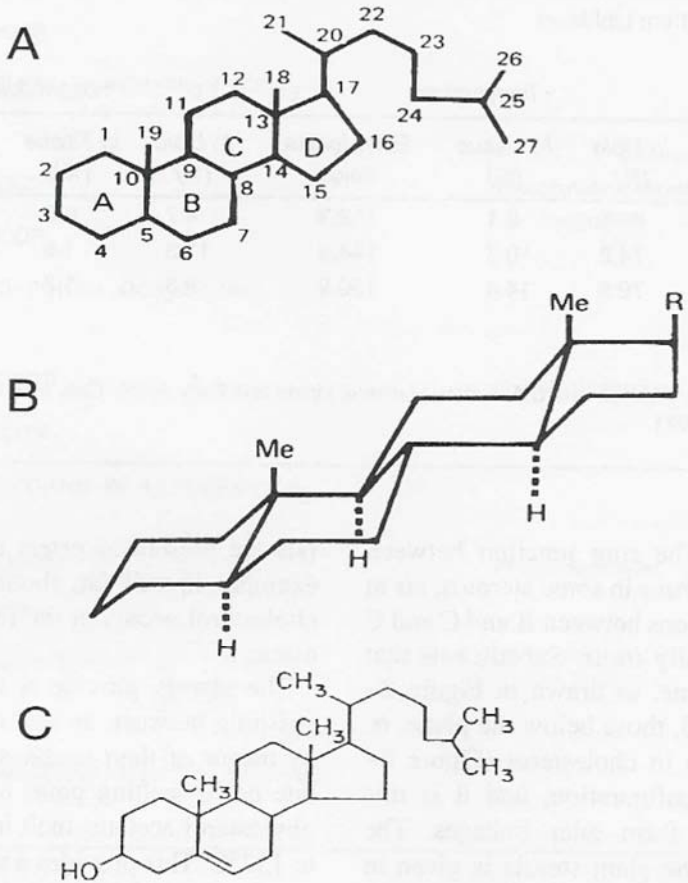


Figure 2–12 Sterols. (**A**) Structure of the Steroid Nucleus, (**B**) Stereochemical Representation, and (C) Cholesterol

Plant sterols

- Sterols and stanols (saturated sterols) – essential plant cell membrane components
- Compete with CHL for absorption in small intestine
- Average consumption –200-400 mg/day. 1 g/day (ester form) see reduction. Max at 2-3 g/d
- Esterified forms can be mgf as water dispersible powder (beverages (orange juice), dairy, energy bars)

Plant sterols

- Health claims must specify on label levels needed to have beneficial effects.
- Benecol margarine (originally marketed as nutritional supplement). Diminicol –plant sterols dissolved in microcrystalline fat matrix. 5 g/day reduce LDL 12% CHL 9%

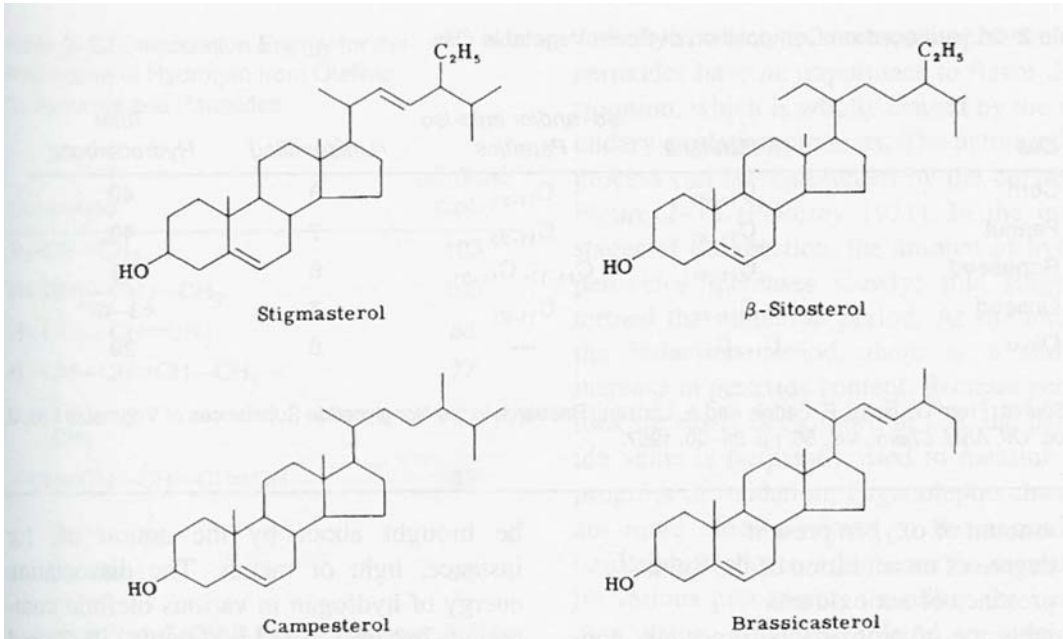
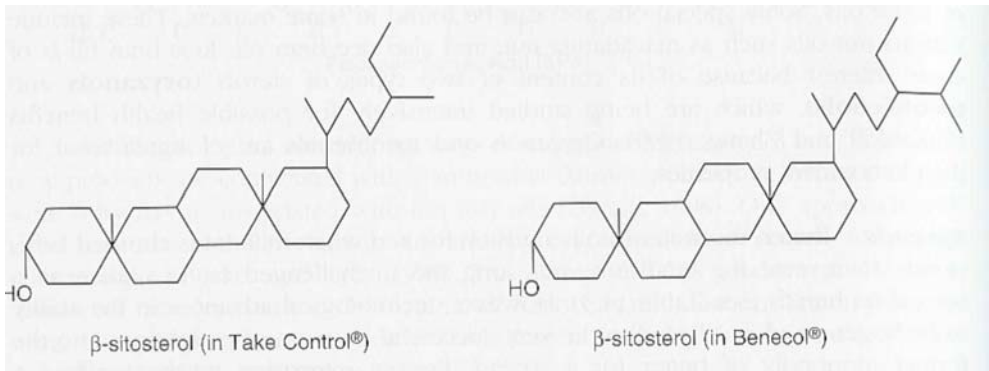


Figure 2–13 Structures of the Plant Sterols



β-sitosterol (in Take Control®)

β-sitosterol (in Benecol®)

Table 12.2 Percent Fat, Fatty Acids, and Cholesterol in Selected Fats

Fat Source	Fat (%)	Fatty Acids (%)[a]			Cholester (mg/100
		Saturated	Monounsaturated	Polyunsaturated	
Animal sources					
Beef tallow[a]	100	49.8	41.8	4.0	109
Butter	81	50.5	23.4	3.0	219
Lard	100	39.2	45.1	11.2	95
Plant sources					
Cocoa butter	100	59.7	32.9	3.0	0
Coconut oil	100	86.5	5.8	1.8	0
Corn oil	100	12.7	24.2	58.7	0
Cottonseed oil	100	25.9	17.8	51.9	0
Olive oil	100	13.5	73.7	8.4	0
Palm oil	100	49.3	37.0	9.3	0
Palm kernel oil	100	81.4	11.4	1.6	0
Peanut oil	100	16.9	46.2	32.0	0
Rapeseed oil[b]	100	5.0	68.1	22.5	0
Safflower oil	100	9.1	12.1	74.5	0
Sesame oil	100	14.2	39.7	41.7	0
Soybean oil	100	14.4	23.3	57.9	0
Sunflower oil	100	10.1	45.4	40.1	0
Margarine, stick					
Corn oil	80.5	13.2	45.8	18.0	0
Safflower, soybean	80.5	13.8	31.7	31.4	0
Soybean	80.5	16.7	39.3	20.9	0
Sunflower, soybean, cottonseed	80.5	11.9	28.5	36.6	0
Margarine, soft (tub)					
Corn oil	80.4	12.1	31.6	31.2	0
Safflower oil	80.4	9.2	23.2	44.5	0
Soybean oil	80.3	13.5	36.4	26.8	0
Sunflower, peanut oils	80.4	16.1	30.7	30.1	0

[a] For specific information on the content of saturated fatty acids (4–18 carbon atoms), monounsaturated fatty aci (16–22 carbon atoms), and polyunsaturated fatty acids (18–22 carbon atoms), refer to the source for this table.

[b] Erucic acid (22 carbon atoms, one double bond) content is 45% and higher.

Adapted from *Composition of Foods: Fats and Oils Raw, Processed, Prepared:* Consumer and Food Economi Institute.

Agriculture Handbook No. 8-4. Science and Education Administration, U.S. Department of Agriculture: Washingto DC, 1979.

Table 2–20 Sterol Content of Fats and Oils

Fat	*Sterol (%)*
Lard	0.12
Beef tallow	0.08
Milk fat	0.3
Herring	0.2–0.6
Cottonseed	1.4
Soybean	0.7
Corn	1.0
Rapeseed	0.4
Coconut	0.08
Cocoa butter	0.2

Table 2–19 Composition of the Unsaponifiable Fraction of Some Fats and Oils

Oils	*Hydrocarbons*	*Squalene*	*Aliphatic Alcohols*	*Terpenic Alcohols*	*Sterols*
Olive	2.8–3.5	32–50	0.5	20–26	20–30
Linseed	3.7–14.0	1.0–3.9	2.5–5.9	29–30	34.5–52
Teaseed	3.4	2.6	—	—	22.7
Soybean	3.8	2.5	4.9	23.2	58.4
Rapeseed	8.7	4.3	7.2	9.2	63.6
Corn	1.4	2.2	5.0	6.7	81.3
Lard	23.8	4.6	2.1	7.1	47.0
Tallow	11.8	1.2	2.4	5.5	64.0

Source: From G. Jacini, E. Fedeli, and A. Lanzani, Research in the Nonglyceride Substances of Vegetable Oils, *J. Assoc. Off. Anal. Chem.*, Vol. 50, pp. 84–90, 1967.

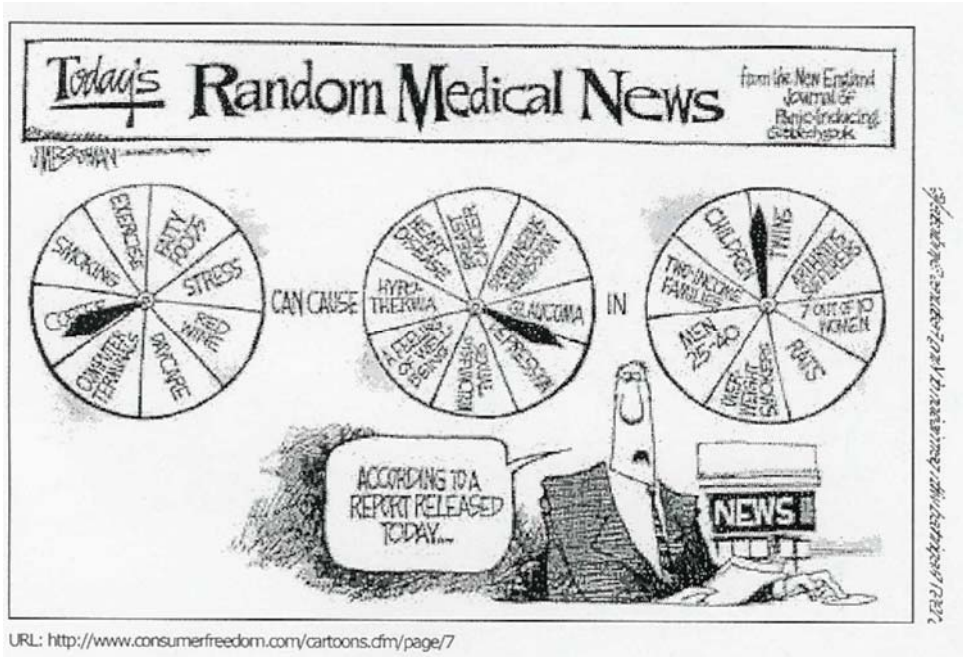


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Table 12.3 Overview of Some Fat Replacements

Trade Name	Type of Base	Calories/g	Where Used	Comments
Simplesse®	Protein	1.3	Ice cream	Cannot be heated
N-Lite	Carbohydrate	4	Many foods	Modified food starch
Stellar™	Carbohydrate	4	Many foods	Cornstarch
Slendid™	Carbohydrate	0	Many foods	Pectin
Oatrim	Carbohydrate	<1	Many foods	Maltodextrins from oat flour
Rice* Trin 3® Complete	Carbohydrate	<1	Many foods	Maltodextrins from rice flour
Avicel®	Carbohydrate	0	Many foods	Cellulose gel
Litesse®	Carbohydrate	1	Many foods	Polydextrose
Paselli Excell	Carbohydrate	4	Many foods	Maltodextrins
Kelcogel®	Carbohydrate	0	Many foods	Gums
Olean	Fat	0	Baked goods	Olestra
Caprenin	Fat	5	Chocolates	Palm kernel/coconut oils
Benefat®	Fat	5	Baked goods	Salatrim (2-C fatty acid(s)
Olestra	Fat/carbohyd.	0	Potato chips	Sucrose polyester

I am required by law to tell you that everything you ordered today may be harmful to your health.

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