Canola Oil and Heart Health

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University of Manitoba

Diabetes Care and Education Practice Group
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Webinar

Richardson Centre for Functional Foods and Nutraceuticals

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Canola Oil

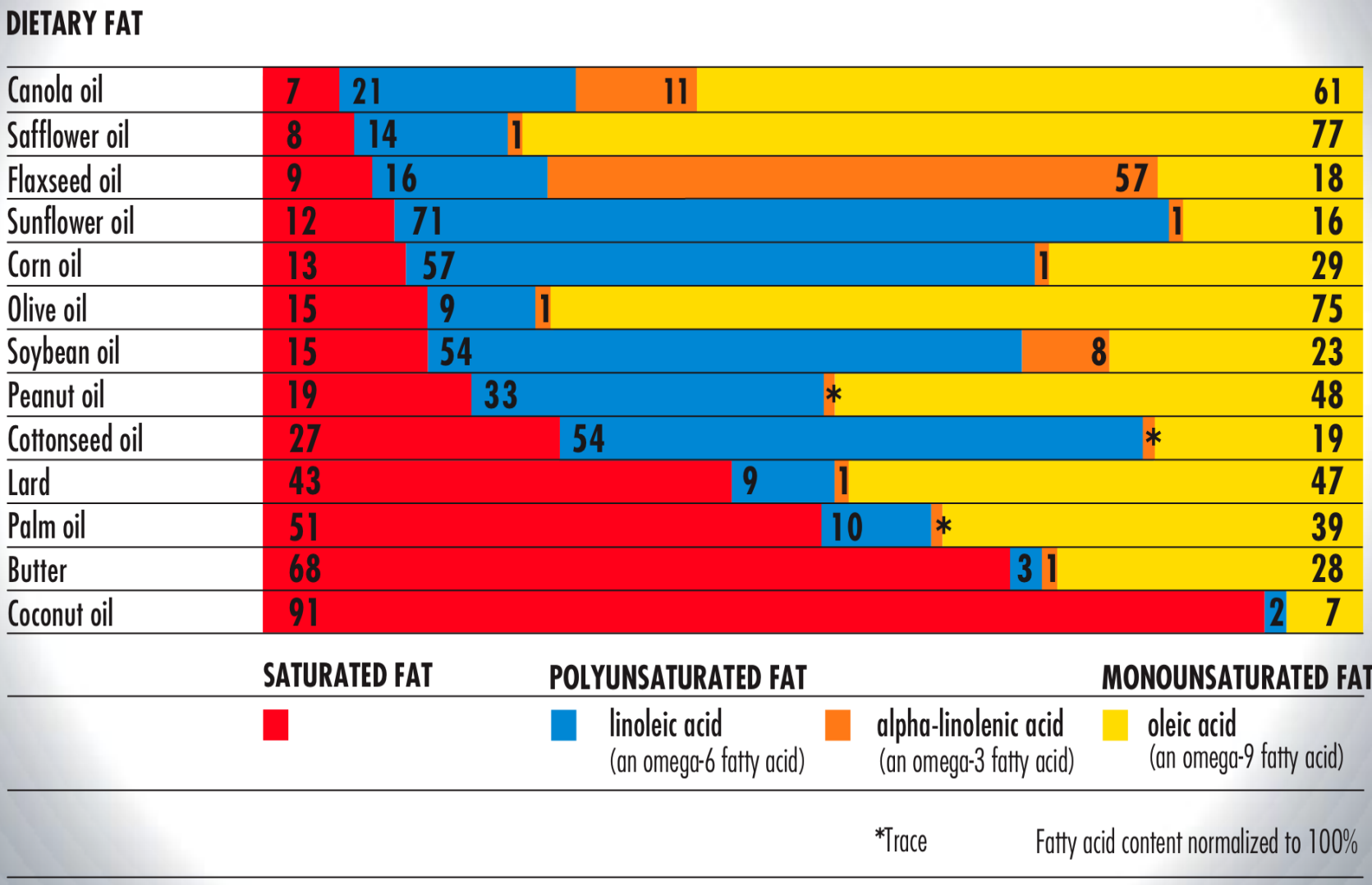
- Canola oil comes from the crushed seeds of canola plants
- Canola is its own plant species, different from rapeseed
- Developed by traditional cross-breeding in the late 1950s/1960s to remove undesirable components of rapeseed (erucic acid and glucosinolates)
- Approved for sale in Canada in 1974 and in the U.S. in 1985 (GRAS)
- FDA authorized qualified health claim for canola oil in October 2006
- Important economic crop in Canada as world's largest exporter of canola seed, oil and meal
- U.S. #1 importer of canola oil and meal from Canada, also grows its own canola
- Canola oil is world's third leading vegetable oil by volume:
  - #1 oil consumed in Canada, #2 in U.S.

Composition of Canola Oil

Canola Oil

- High in monounsaturated fat
- High in omega-3 fat
- High in plant sterols
- Antioxidant vitamin E
- Low in saturated fat
- Other health-promoting constituents

Comparison of Dietary Fats & Oils



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Dietary Fat Intakes & Recommendations

	CURRENT INTAKES		RECOMMENDED INTAKE	
FAT (% of daily energy)	MEDITERRANEAN[1]	UNITED STATES[2]	ADA/DC (Dietary Guidelines 2005)[3]	AHA NCEP (ATP III)[4]
Total Fat	33-40%	33%	20-35%	25-35%*
Saturated	≤ 8%	11%	< 10%	< 7%
Monounsaturated	16-29%	12%	< 25%	≤ 20%
Polyunsaturated	< 7%	< 7%	< 10%	≤ 10%
linoleic acid	--	14.7 g/d	5-10% (12-17g/d)	5-10%
α-linoleinc acid	--	1.5 g/d	0.6-1.2% (1.1-1.6 g/d)	1.5-3.0 g/d
n-6:n-3 ratio	--	9.8:1	4:1	--
EPA+DHA	--	100-130 mg/d	500 mg/d	900 mg/d

* The 25–35% fat recommendation allows for increased intake of unsaturated fat in place of carbohydrates in people with the metabolic syndrome or diabetes

Note: n-6:n-3 ratio decreased from 12.4:1 to 10.6:1 from 1985 to 1994, reflected by a ~5.5-fold increase in canola oil use[5]

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[1]Perez-Jimenez et al., *Atherosclerosis* 2002;163:385-98; [2]Means of US male and females (ages 20-59) from the NHANES, 1999-2002; [3]ADA Reports. *J Am Diet Assoc* 2007;107:1599-1611; [4]*JAMA* 2001 May 16;285:2486-97; [5]Kris-Etherton et al., *Am J Clin Nutr* 2000;71:179-

Current Research

Dietary Modeling Shows that the Substitution of Canola Oil for Fats Commonly Used in the United States Would Increase Compliance with Dietary Recommendations for Fatty Acids

GUY H. JOHNSON, PhD; DEBRA R. KEAST, PhD; PENNY M. KRIS-ETHERTON, PhD, RD

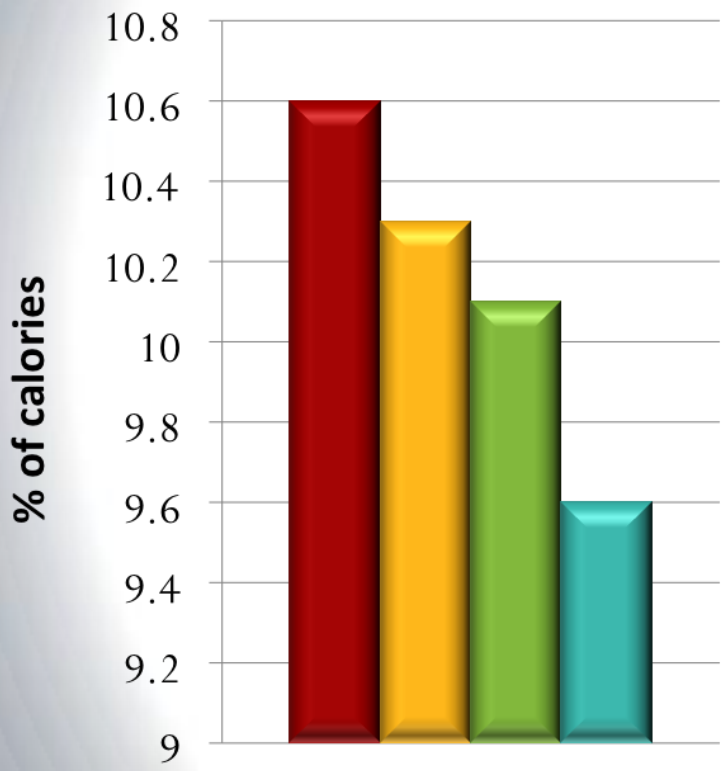
Objective: "To examine the effect of substituting canola oil for selected vegetable oils and canola oil-based margarine for other spreads on energy, fatty acid, and cholesterol intakes among US adults".

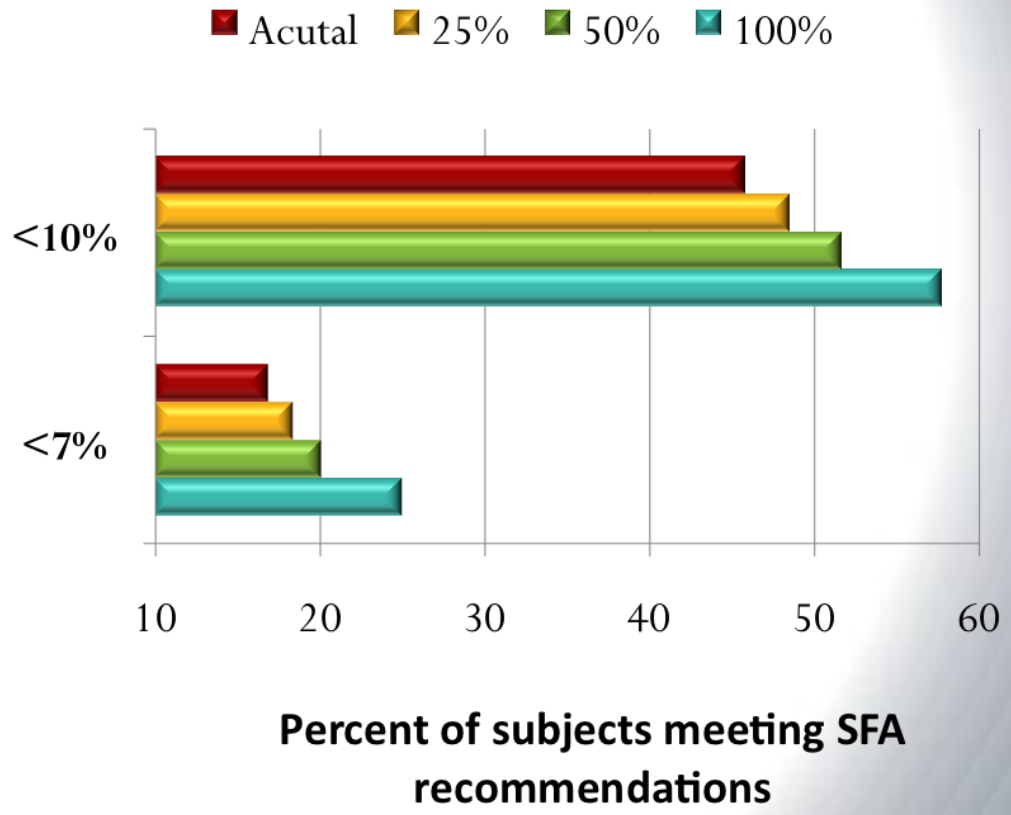
Design: Adults aged ≥ 20 years (n=8,983) from the 1999-2002 National Health and Nutrition Examination Survey (NHANES)

• 25%, 50%, 100% substitution of canola oil and canola oil-based margarine for dietary corn, cottonseed, safflower, soybean, and other vegetable oils and spreads.

Johnson et al., *J Am Diet Assoc* 2007;107:1726-34

Substitution of Canola Oil for Other Oils; Effect on SFA Intakes and Percent of People Meeting Current Dietary Recommendations





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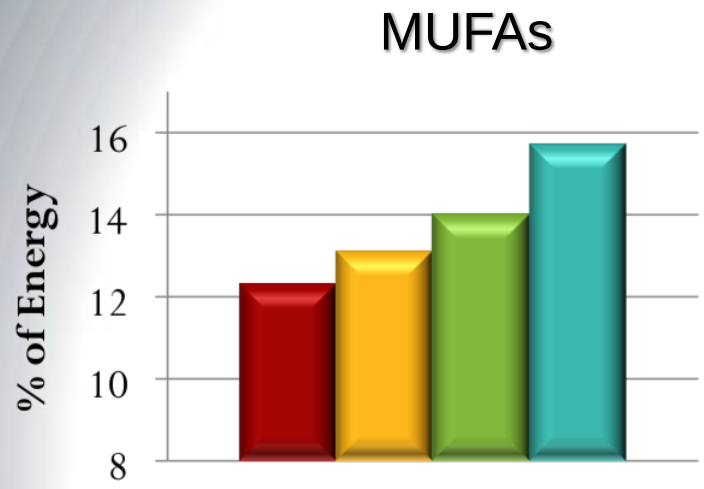
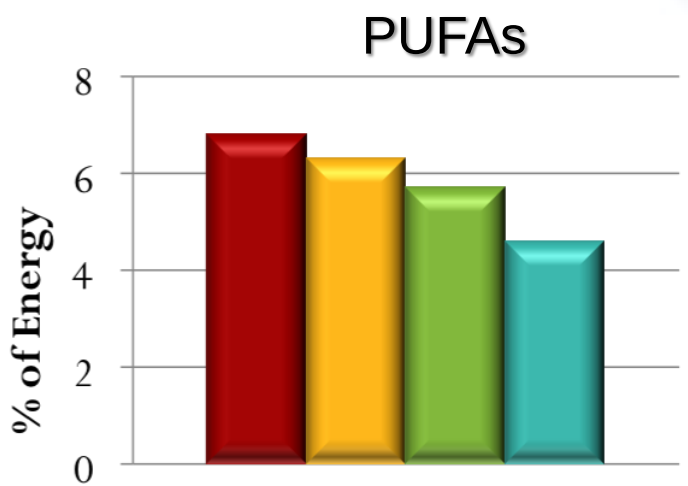
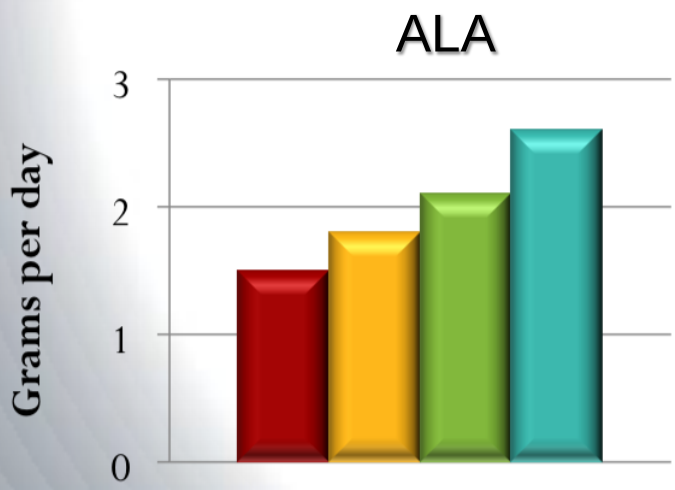
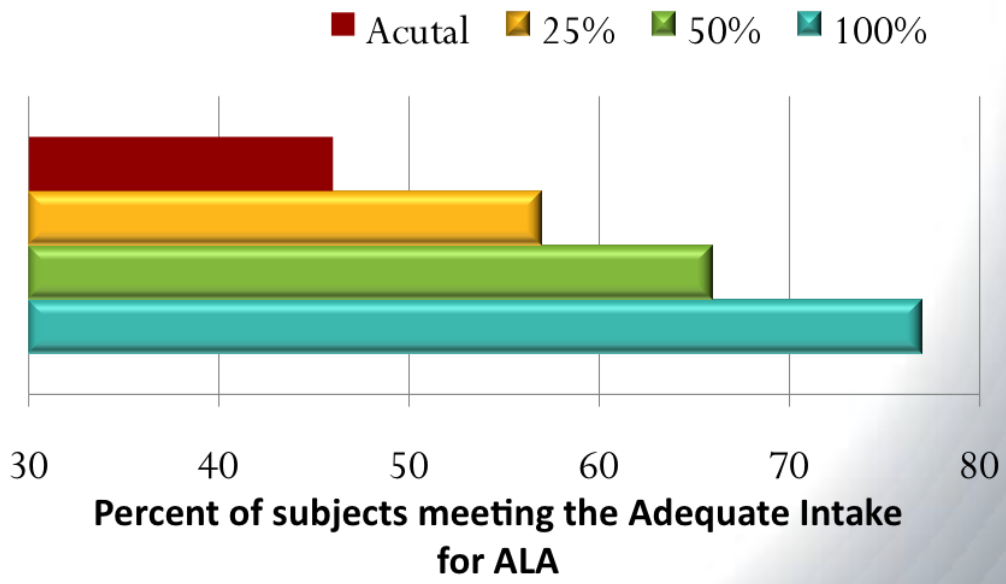
Adapted from: Johnson et al., *J Am Diet Assoc* 2007;107:1726-34

Substitution of Canola Oil for Other Oils; Effect on MUFA, PUFA, and ALA Intakes









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Adapted from: Johnson et al., *J Am Diet Assoc* 2007;107:1726-34

Current Research

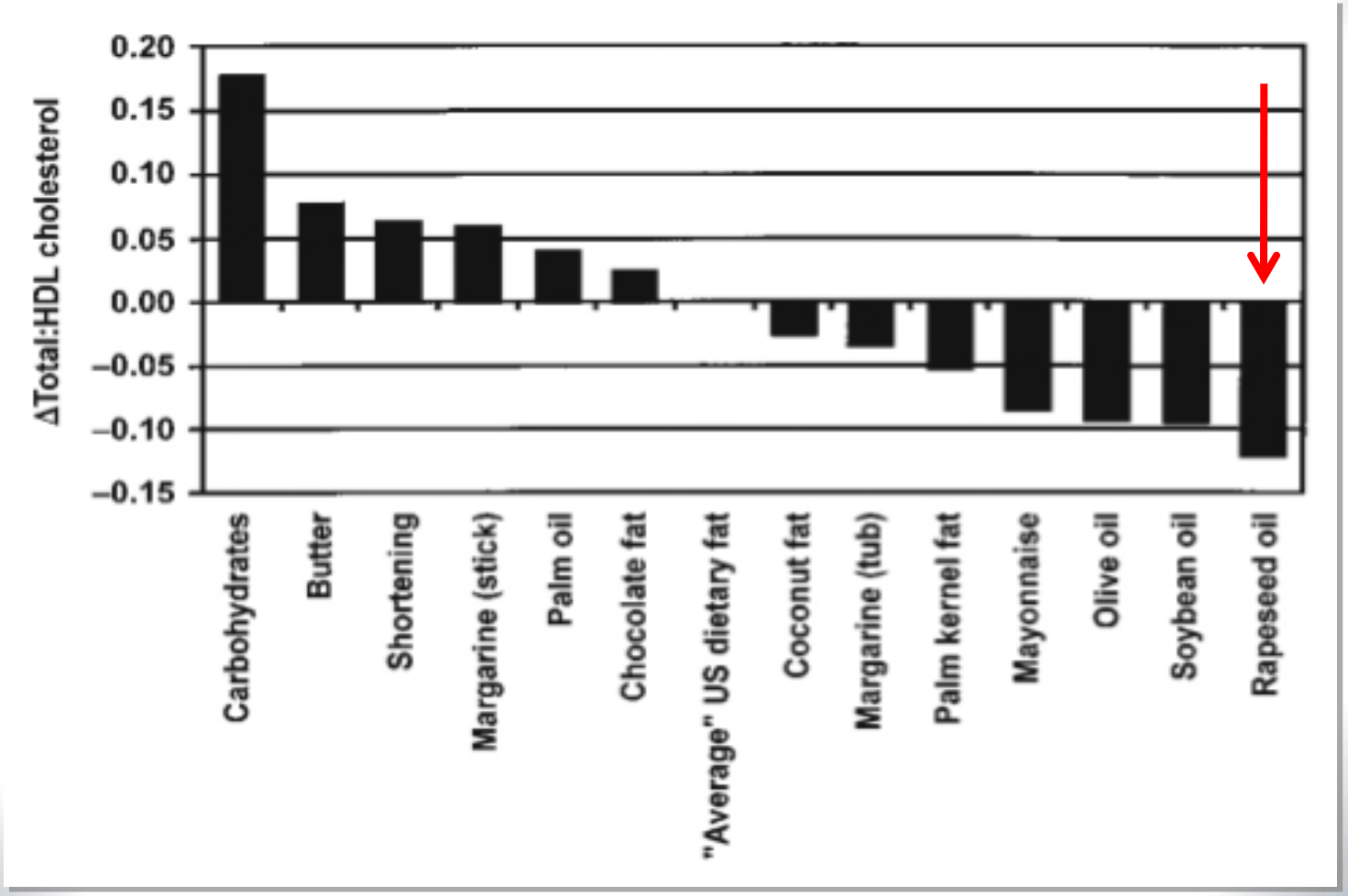
Dietary Modeling Shows that the Substitution of Canola Oil for Fats Commonly Used in the United States Would Increase Compliance with Dietary Recommendations for Fatty Acids

GUY H. JOHNSON, PhD; DEBRA R. KEAST, PhD; PENNY M. KRIS-ETHERTON, PhD, RD

Conclusion: "Substitution of canola oil and canola oil-based margarine for most other vegetable oils and spreads increased compliance with dietary recommendations for saturated fatty acid, monounsaturated fatty acid, and α-linolenic acid, but not for linoleic acid, among US adults".

Johnson et al., *J Am Diet Assoc* 2007;107:1726-34

Isoenergetic Replacement of 10% Energy from Mixed Fat in the Average American Diet with a Specific Fat or CHO



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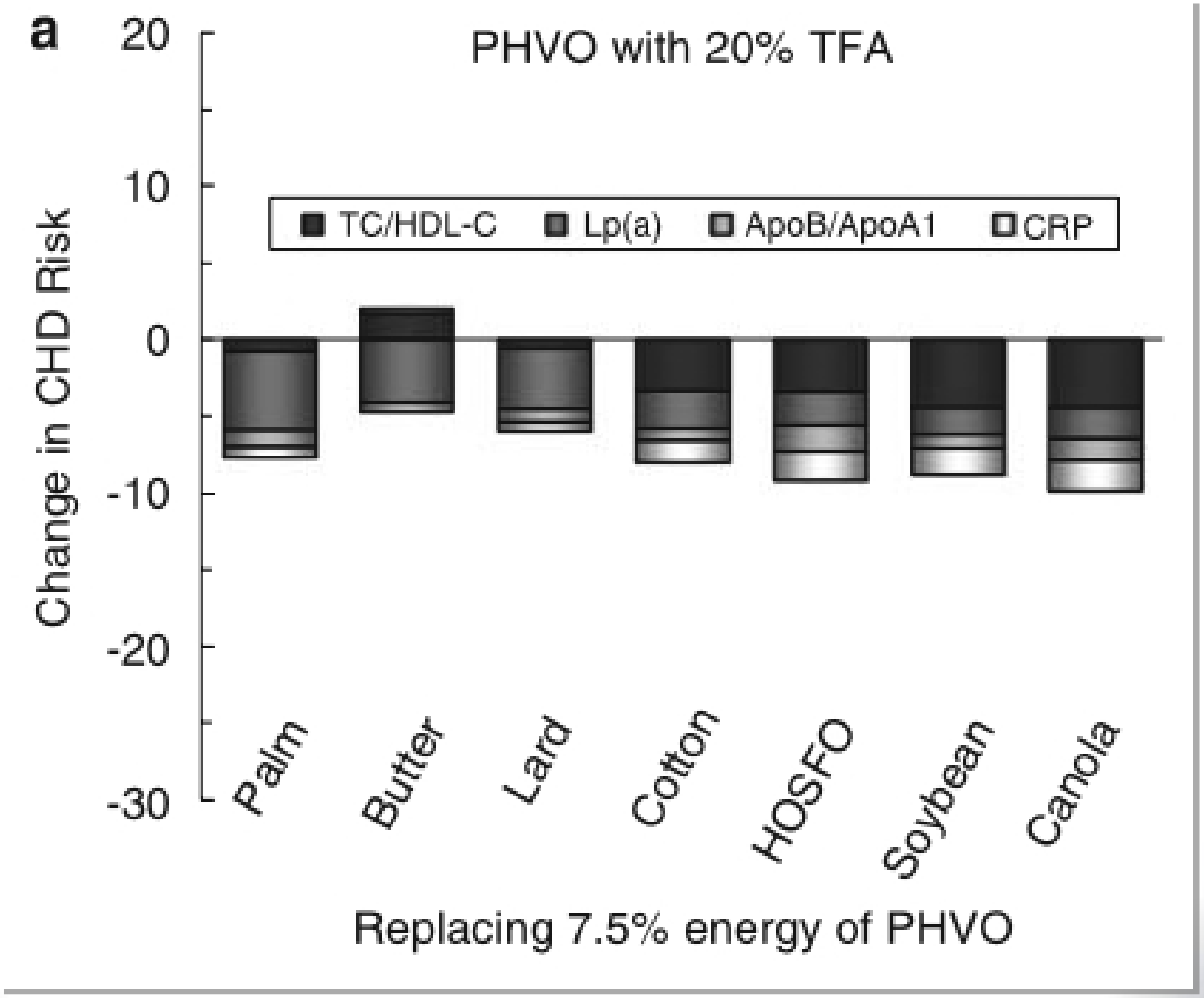
Mensink et al., *Am J Clin Nutr* 2003;77:1146-55

Isoenergetic Replacement of 7.5% Energy from Partially Hydrogenated Vegetable Oil (20% TFAs) with Alternative Fats or Oils



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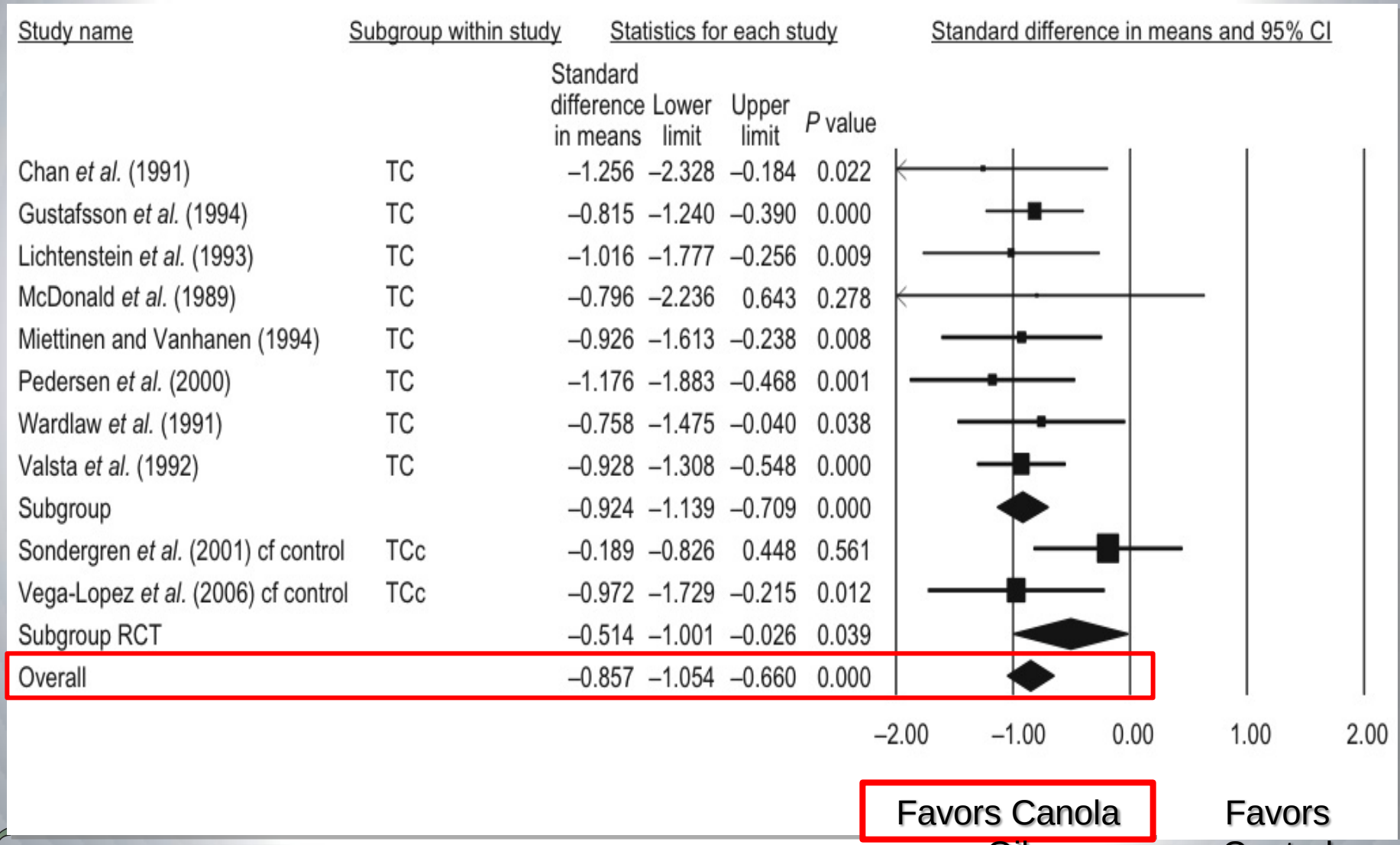
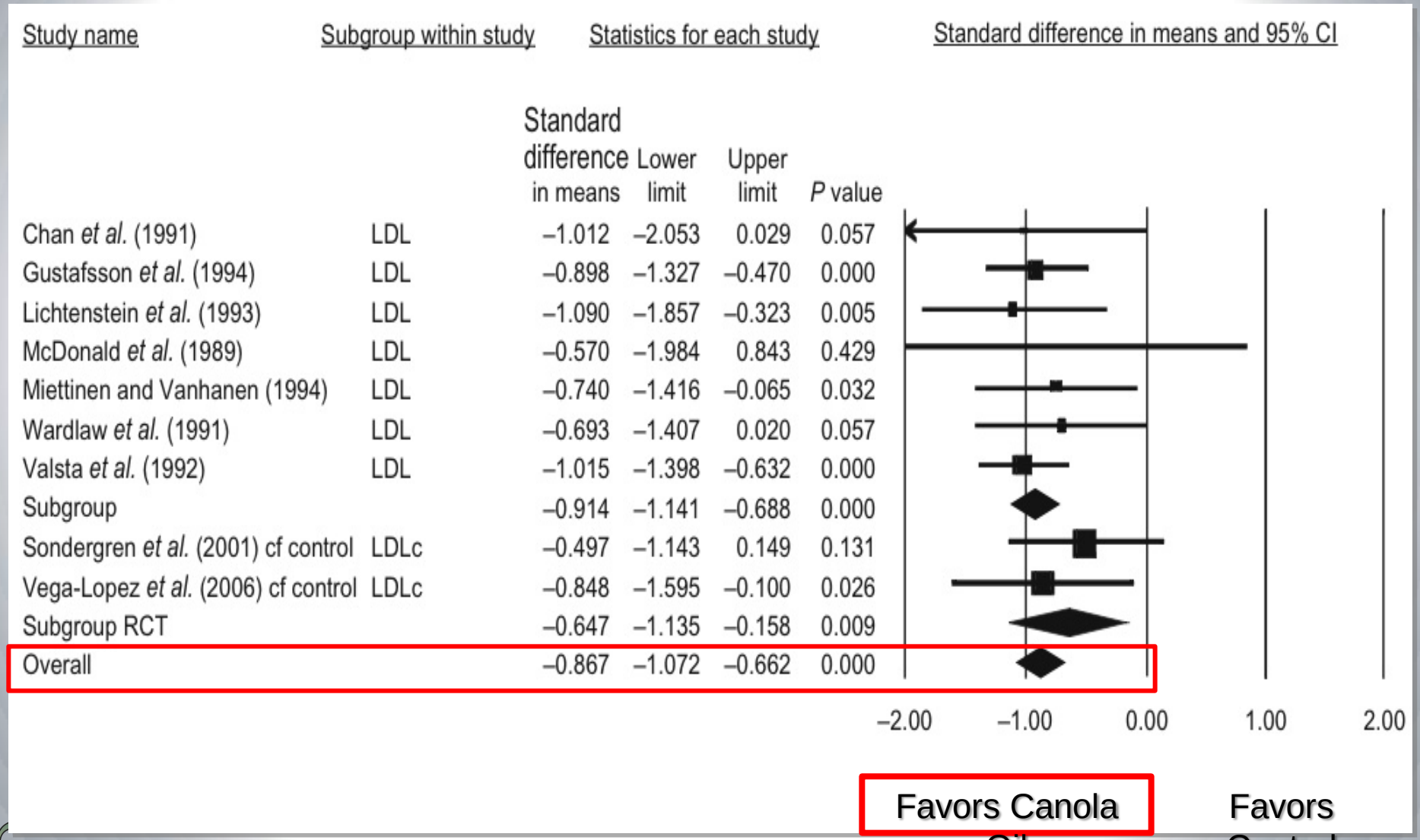
Mozaffarian & Clarke, *Eur J Clin Nutr* 2009;63:S22-S33

Mean Difference in Total-Cholesterol in Canola Oil Intervention Studies



Harland. *Nutrition Bulletin* 2009;34:174-84

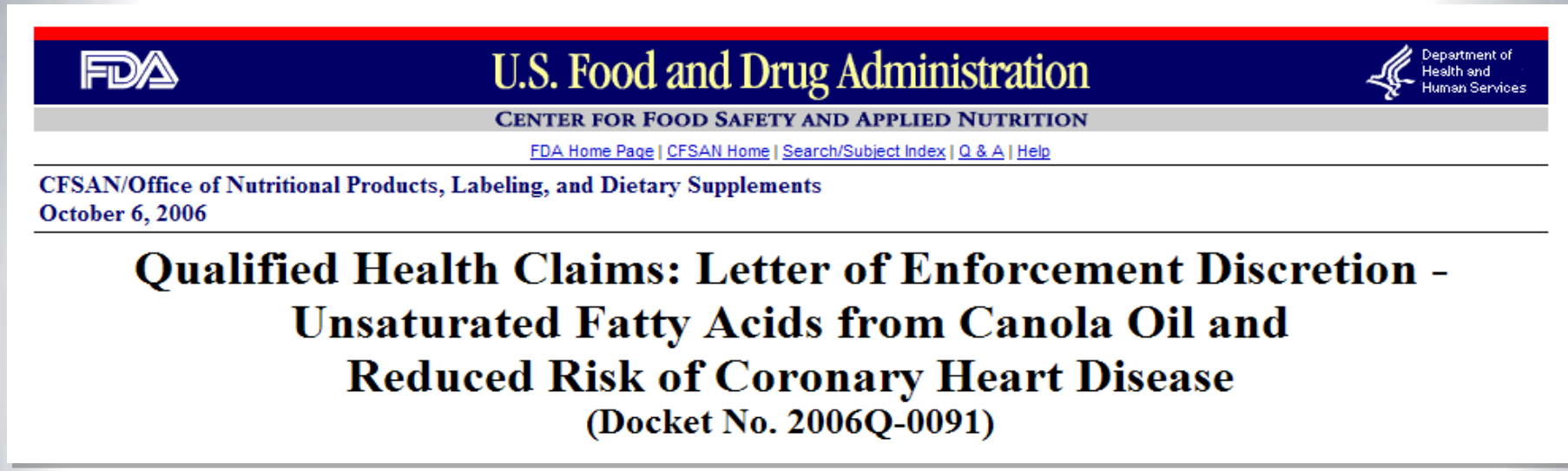
Mean Difference in LDL-Cholesterol in Canola Oil Intervention Studies



Study name	Subgroup within study	Standard difference in means	Lower limit	Upper limit	*P* value
Chan *et al.* (1991)	LDL	–1.012	–2.053	0.029	0.057
Gustafsson *et al.* (1994)	LDL	–0.898	–1.327	–0.470	0.000
Lichtenstein *et al.* (1993)	LDL	–1.090	–1.857	–0.323	0.005
McDonald *et al.* (1989)	LDL	–0.570	–1.984	0.843	0.429
Miettinen and Vanhanen (1994)	LDL	–0.740	–1.416	–0.065	0.032
Wardlaw *et al.* (1991)	LDL	–0.693	–1.407	0.020	0.057
Valsta *et al.* (1992)	LDL	–1.015	–1.398	–0.632	0.000
Subgroup		–0.914	–1.141	–0.688	0.000
Sondergren *et al.* (2001) cf control	LDLc	–0.497	–1.143	0.149	0.131
Vega-Lopez *et al.* (2006) cf control	LDLc	–0.848	–1.595	–0.100	0.026
Subgroup RCT		–0.647	–1.135	–0.158	0.009
Overall		–0.867	–1.072	–0.662	0.000

Harland. *Nutrition Bulletin* 2009;34:174-84

USDA 2006: Qualified Health Claim for Canola Oil



FDA U.S. Food and Drug Administration — Department of Health and Human Services

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CFSAN/Office of Nutritional Products, Labeling, and Dietary Supplements
October 6, 2006

Qualified Health Claims: Letter of Enforcement Discretion - Unsaturated Fatty Acids from Canola Oil and Reduced Risk of Coronary Heart Disease
(Docket No. 2006Q-0091)

"Limited and not conclusive scientific evidence suggests that eating about 1½ tablespoons (19 grams) of canola oil daily may reduce the risk of coronary heart disease due to the unsaturated fat content in canola oil. To achieve this possible benefit, canola oil is to replace a similar amount of saturated fat and not increase the total number of calories you eat in a day."

http://www.fda.gov/Food/LabelingNutrition/LabelClaims/QualifiedHealthClaims/ucm072958.htm

Composition of Canola Oil

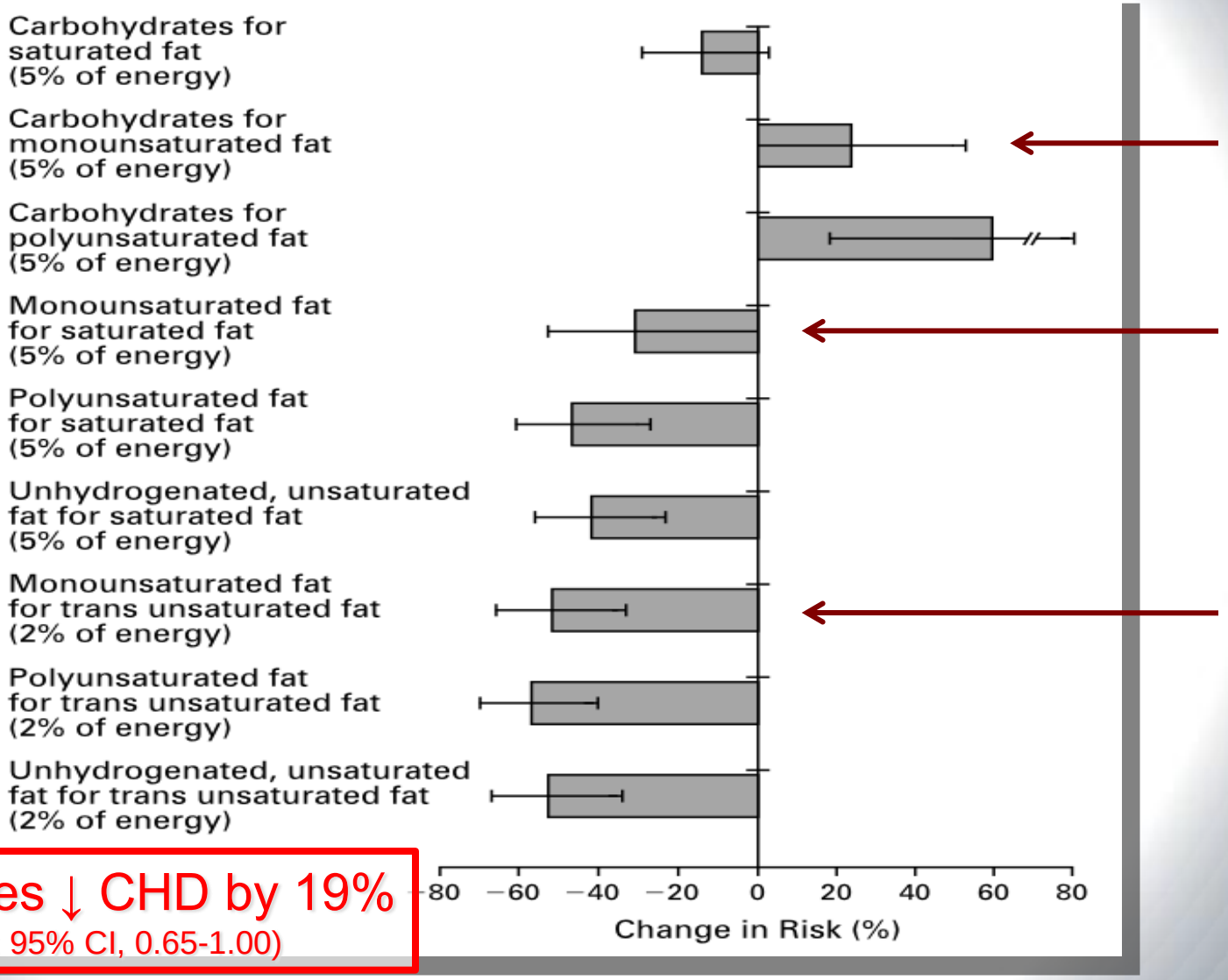
Canola Oil

- **High in monounsaturated fat**
- High in omega-3 fat
- High in plant sterols
- Antioxidant vitamin E
- Low in saturated fat
- Other health-promoting constituents

Nurses' Health Study

14 year follow-up, n=80,082 women

Estimated % change in CHD risk with dietary 5% isocaloric substitution



MUFA intakes ↓ CHD by 19%

(RR=0.81; 95% CI, 0.65-1.00)

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Hu et al., *N Engl J Med* 1997;337:1491-9

MUFAs & CHD Risk Reduction

Table 5. Summary of the Evidence of a Causal Association Between Diet and Coronary Heart Disease, as Determined From Examination of Prospective Cohort Studies Using the Bradford Hill Guidelines and Consistency With Findings From RCTs[a]

Evidence of a Causal Association From Cohort Studies	Cohort Data Only	Supported by RCTs
Strong		
"Mediterranean" diet[b]		Yes
High-quality diet	✓	
Vegetables	✓	
Nuts	✓	
Trans–fatty acids	✓	
Glycemic index or load	✓	
"Prudent" diet[c,d]	✓	
"Western" diet[d,e]	✓	
Monounsaturated fatty acids[d]	✓	
Moderate		
Fish		No
Marine ω-3 fatty acids		Yes
Dietary folate	✓	
Supplementary folate		RCT data only
Whole grains	✓	
Dietary vitamin E	✓	
Dietary beta carotene	✓	
Supplementary beta carotene		RCT data only
Dietary vitamin C	✓	
Alcohol, light/moderate consumption	✓	
Alcohol, heavy consumption	✓	
Fruits	✓	
Fiber	✓	
Weak		
Supplementary vitamin E		Yes
Supplementary ascorbic acid		Yes
Total fat		Yes
Saturated fatty acids	✓	
Polyunsaturated fatty acids		Yes
ω-3 Fatty acids, total		No[f]
Meat	✓	
Eggs		
Milk		

REVIEW ARTICLE

A Systematic Review of the Evidence Supporting a Causal Link Between Dietary Factors and Coronary Heart Disease

Andrew Mente, PhD; Lawrence de Koning, MSc; Harry S. Shannon, PhD; Sonia S. Anand, MD, PhD, FRCPC

Background: Although a we
etary factors and coronary heart
of the evidence supporting valu
evaluated systematically in a s

Methods: We conducted
MEDLINE for prospective co
tized trials investigating dietar
CHD. We used the Bradford H
causation score based on 4 c
tency, temporality, and coher
posure in cohort studies and
with the findings of randomiz

Results: Strong evidence suppo
teria satisfied) of protective facto
etables, nuts, and "Mediterranea
patterns with CHD, and associa
cluding intake of *trans*–fatty acid
cemic index or load. Among stu

- Prospective cohort studies & RCTs were used to evaluate dietary exposures related to CHD
- 223 prospective studies; 66 RCTs; 305 other study designs
- Bradford Hill Guidelines score based on 4 criteria:
  - ✓Strength
  - ✓consistency
  - ✓temporality

MUFA intakes ↓ CHD events by 20%
(RR=0.80; 95% CI, 0.67-0.93)

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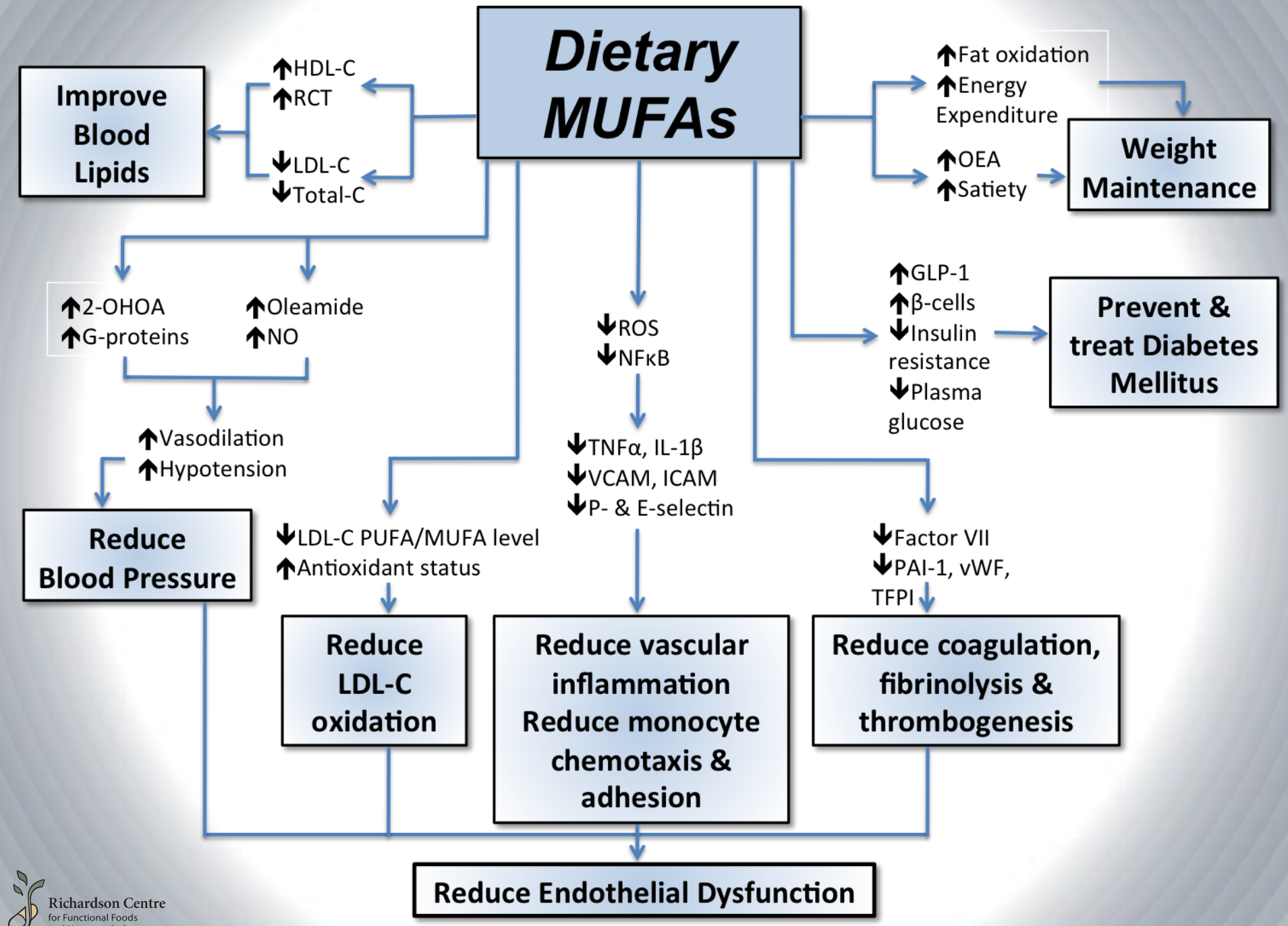
Mente et al., *Arch Intern Med* 2009;169:659-69



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MUFAs Improves CVD Risk Factors

- **Blood Lipids**

  Harland. *Nutrition Bulletin* 2009; Mensink et al. *Am J Clin Nutr* 2003

- **Blood Pressure**

  Swain et al. *J Am Diet Assoc* 2008; Hall. *Nutr Rev* 2009

- **Insulin Sensitivity**

  Uusitupa et al. *Am J Clin Nutr* 1994; Tierney & Roche. *Mol Nutr Food Res* 2007

- **Weight Management and Body Composition**

  Bergouignan et al. *Prog Lipid Res* 2009

- **Endothelial Dysfunction**

  Perez-Jimenez et al. *Atherosclerosis* 2002

  - **LDL Oxidation Susceptibility**

    Egert et al. *Eur J Clin Nutr* 2007; Nielsen *Br J Nutr* 2002

  - **Platelet aggregation**

    Smith et al. *Br J Nutr* 2009

References:

Canola Oil Studies (Red)

MUFA Review Articles (Black)

MUFA rich diet; hypertension, lipids, and estimated CHD risk

Characteristics of the Diet Patterns Tested in the Optimal Macronutrient Intake Trial to Prevent Heart Disease (OmniHeart): Options for a Heart-Healthy Diet

JANIS F. SWAIN, MS, RD; PHYLLIS B. McCARRON, MS, RD; EILEEN F. HAMILTON, DTR; FRANK M. SACKS, MD; LAWRENCE J. APPEL, MD

Canola and olive oils

Table 3. The Optimal Macronutrient Intake Trial to Prevent Heart Disease (OmniHeart) risk factor measures and mean changes from baseline (11) by diet pattern[a]

Clinical measure/risk	n	Baseline	CARB[b]	PROT[c]	UNSAT[d]
		mean±SD[e]	← *mean change from baseline±SD* →		
Systolic Blood Pressure (mm Hg)					
All	164	131.2±9.4	−8.2±−9.6 to −6.8	−9.5±−10.9 to −8.2	−9.3±−10.6 to −8.0
Hypertension, stage 1[f]	32	146.5±5.7	−12.9±−16.6 to −9.2	−16.1±−19.7 to −12.5	−15.8±−19.4 to −12.3
LDL[g] cholesterol (mg/dL)[h]					
All	161	129.2±32.4	−11.6±−14.6 to −8.6	−14.2±−17.5 to −10.9	−13.1±−16.4 to −9.8
≥130 (mg/dL)[h]	32	156.7±21.0	−19.8±−24.2 to −15.5	−23.6±−28.5 to −18.8	−21.9±−26.9 to −16.8
HDL[i] cholesterol (mg/dL)[h]	164	50.0±16.1	−1.4±−2.5 to −0.3	−2.6±−3.6 to −1.6	−0.3±−1.3 to 0.7
Triglyceride (mg/dL)[j]	164	101.5±75 to 159	0.1±−8.6 to 8.8	−16.4±−25.5 to −7.3	−9.3±−17.5 to −1.2
Estimated 10-y coronary heart disease risk[k] (%)		5.1	4.3	4.0	4.1

"Moderate replacement of carbohydrate with either protein or unsaturated fat further reduced CVD risk"

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Swain et al., *J Am Diet Assoc* 2008;108:257-65

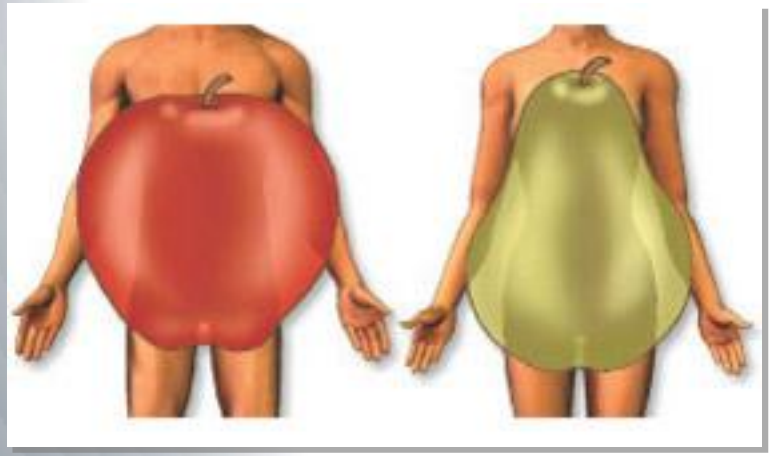
MUFAs & Body Fat Distribution

Clinical Care/Education/Nutrition
ORIGINAL ARTICLE

Monounsaturated Fat–Rich Diet Prevents Central Body Fat Distribution and Decreases Postprandial Adiponectin Expression Induced by a Carbohydrate-Rich Diet in Insulin-Resistant Subjects

J.A. PANIAGUA, MD, PHD[1,2]
A. GALLEGO DE LA SACRISTANA, MD[1]
I. ROMERO, PHD[1]
A. VIDAL-PUIG, MD, PHD[3]
J.M. LATRE, MD, PHD[4]
E. SANCHEZ, MD[1]
P. PEREZ-MARTINEZ, MD, PHD[1,2]
J. LOPEZ-MIRANDA, MD, PHD[1,2]
F. PEREZ-JIMENEZ, MD, PHD[1]

A positive energy balance, which leads to obesity, is associated with insulin resistance and an increased risk of type 2 diabetes. According to our studies in rodents, adipose tissue expandability seems to be a key



Results – After the CHO-rich diet, subjects fat mass was redistributed from the periphery to the abdomen, compared to the MUFA-rich diet. Furthermore, the CHO-rich diet decreased postprandial adiponectin levels and insulin sensitivity, compared to the MUFA-rich diet.

Paniagua et al., *Diabetes Care* 2007;30:1717-23

Composition of Canola Oil

Canola Oil

- High in monounsaturated fat
- **High omega-3 fat**
- High in plant sterols
- Antioxidant vitamin E
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- Other health-promoting constituents

Fatty Acid Composition of Canola Oil

Nutrition Facts		
Amount per serving	**Canada** 10 mL (2 tsp.)	**USA** 14 g (1 Tbsp.)
Calories	80	120
Fat	9 g	14 g
Saturated + trans	0.6 g 0 g	1 g 0 g
Polyunsaturated Omega-6 Omega-3	3 g 2 g 0.9 g	4 g 2.8 g 1.3 g
Monounsaturated	6 g	8 g
Cholesterol	0 g	0 g

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Prospective Cohort Studies of ALA Intakes and CHD Risk

Study	Subjects	Intakes of ALA	RR (95% CI or *P* value)
MRFIT Dolecek et al., 1992	6,250 men	Quintile extremes	↓ 40% ($P < 0.04$)
Health Professionals Ascherio et al., 1996	43,757 men	↑ 1% Energy	↓ 59% (20-79%)
Finland ATBC Pietinen et al., 1997	21,930 male smokers	Quintile extremes	No significant association
Nurses Health Hu et al., 1999	76,283 women	1.36 vs. 0.71 g/d	↓ 45% (6-68%)
Zutphen Elderly Study Oomen et al., 2001	677 older men	Tertile extremes	No significant association
Iowa Women's Health Folsom et al., 2004	41,836 women	1.21 vs. 0.96 g/d	↓ 15% (*P* trend 0.01)
Health Professionals Mozaffarian et al., 2005	45,722 men	↑ 1 g/d	↓ 16% (0-29%) ↓ 47% (17-66%) for low seafood eaters

A study involving eleven eastern European countries showed that increase in ALA consumption from **rapeseed oil** attributed in reducing the CHD mortality (r = -0.84 in men and -0.83 in women) (Zatonski et al., Eur J Epidemiol 2008;23:3–10)

Table adapted from: Mozaffarian et al., *Altern Ther Health Med* 2005;11:24-30

THE LANCET

Mediterranean alpha-linolenic acid-rich diet in secondary prevention of coronary heart disease

Michel de Lorgeril, Serge Renaud, Nicole Mamelle, Patricia Salen, Jean-Louis Martin, Isabelle Monjaud, Jeannine Guidollet, Paul Touboul, Jacques Delaye

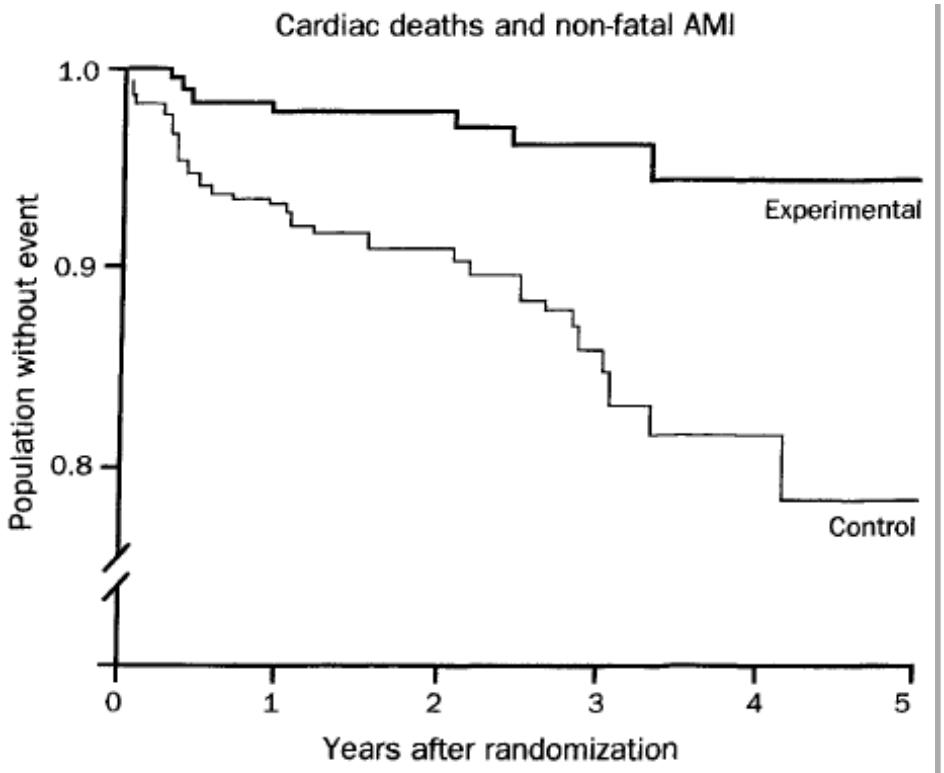

Figure 2: **Survival curves combined cardiac death and non-fatal acute myocardial infarction (AMI)**

Log rank test, using only the time of the first event.

Experimental group diet added **canola oil and canola oil-based margarine**…

…contributing to the **3-fold increase in daily ALA intakes**

Control=0.27% energy from ALA

Experimental=0.81% energy from ALA

↓ 73% (95% CI: 41-88%) CHD risk reduction with ALA-rich diet

De Lorgeril et al., *Lancet* 1994;343:1454-59

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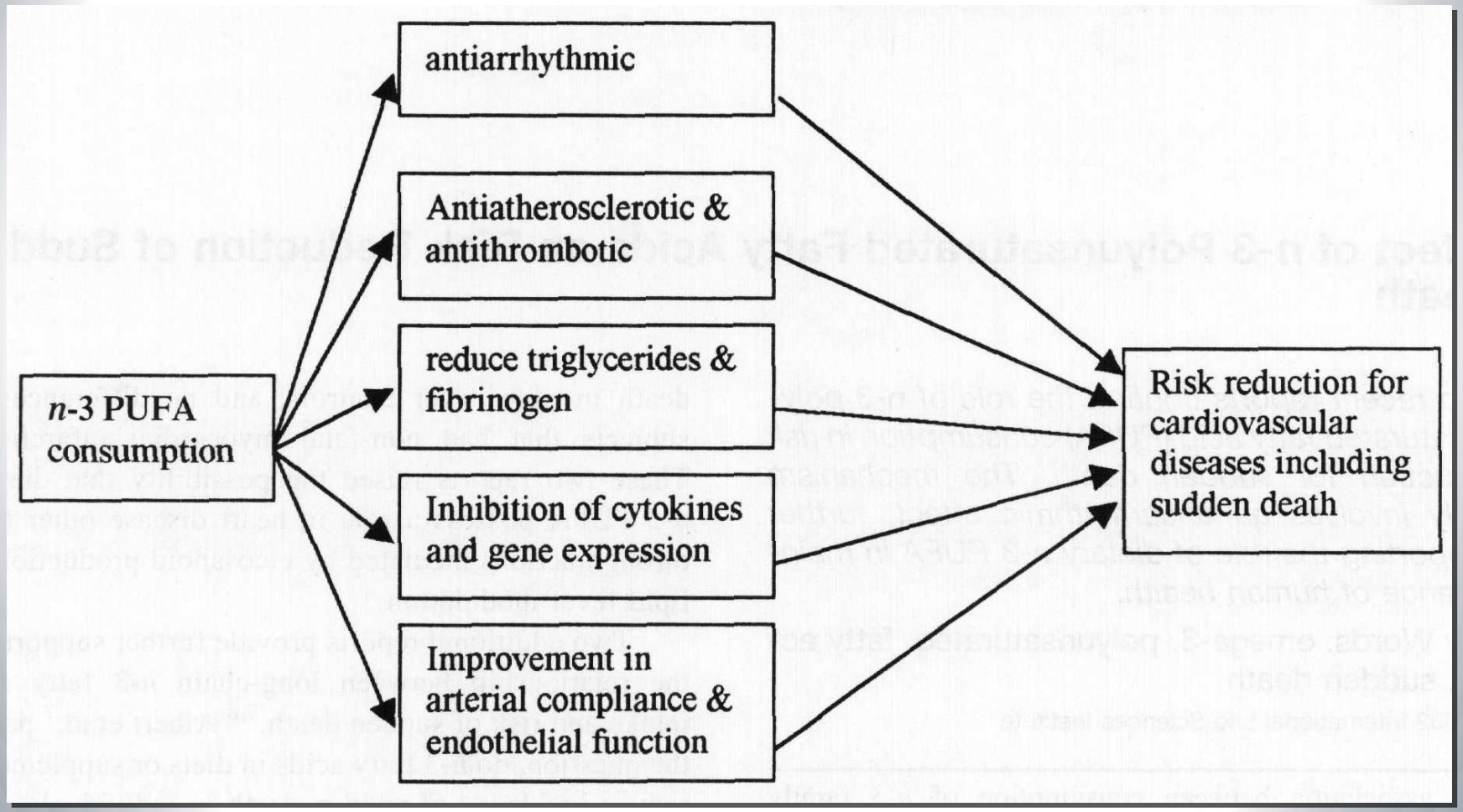
Mechanisms of Action by which Omega-3 Fatty Acids may Decrease CVD Risk



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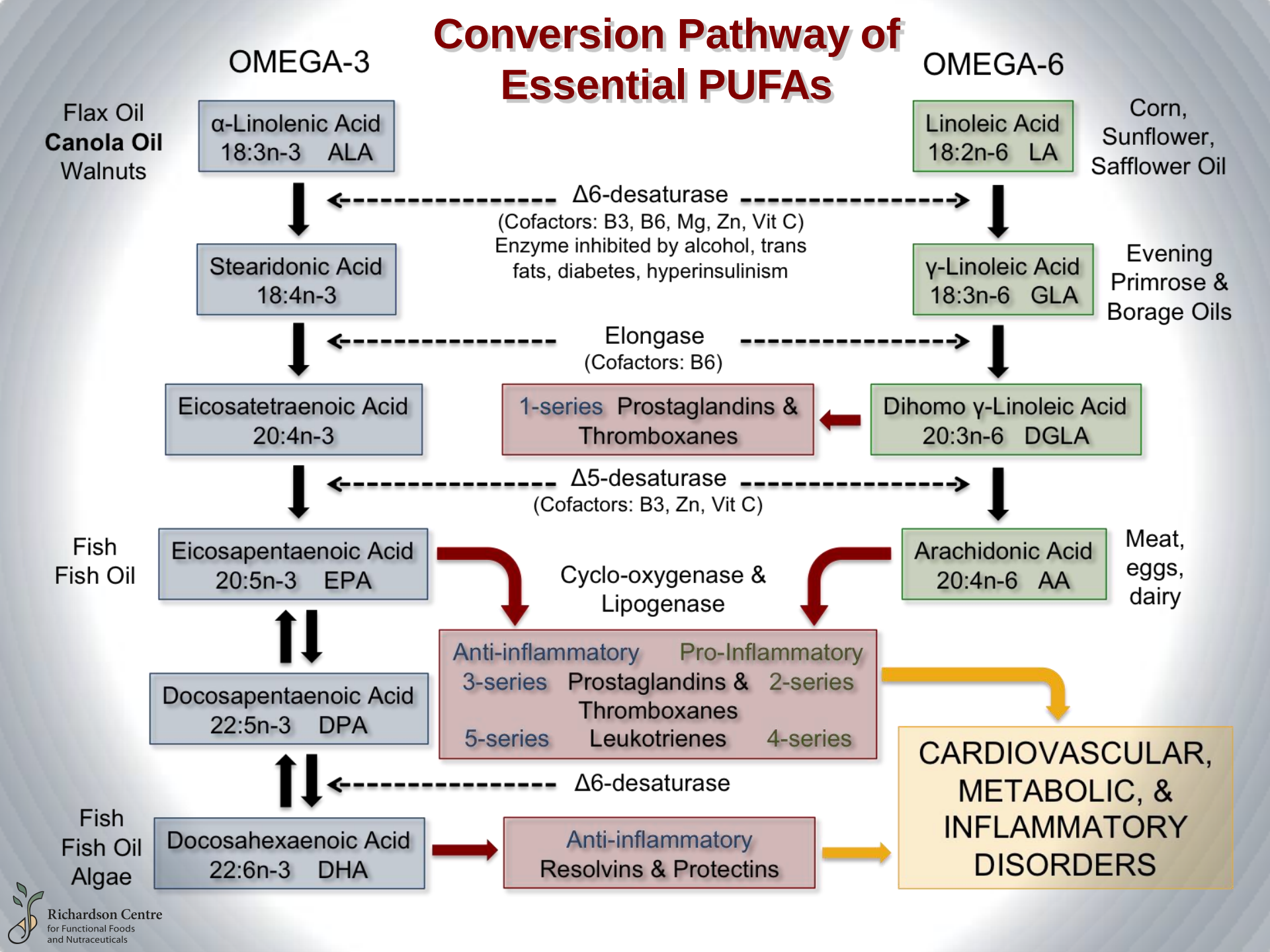
Jones & Lau, *Nutr Rev* 2002;60:407-9

Conversion Pathway of Essential PUFAs



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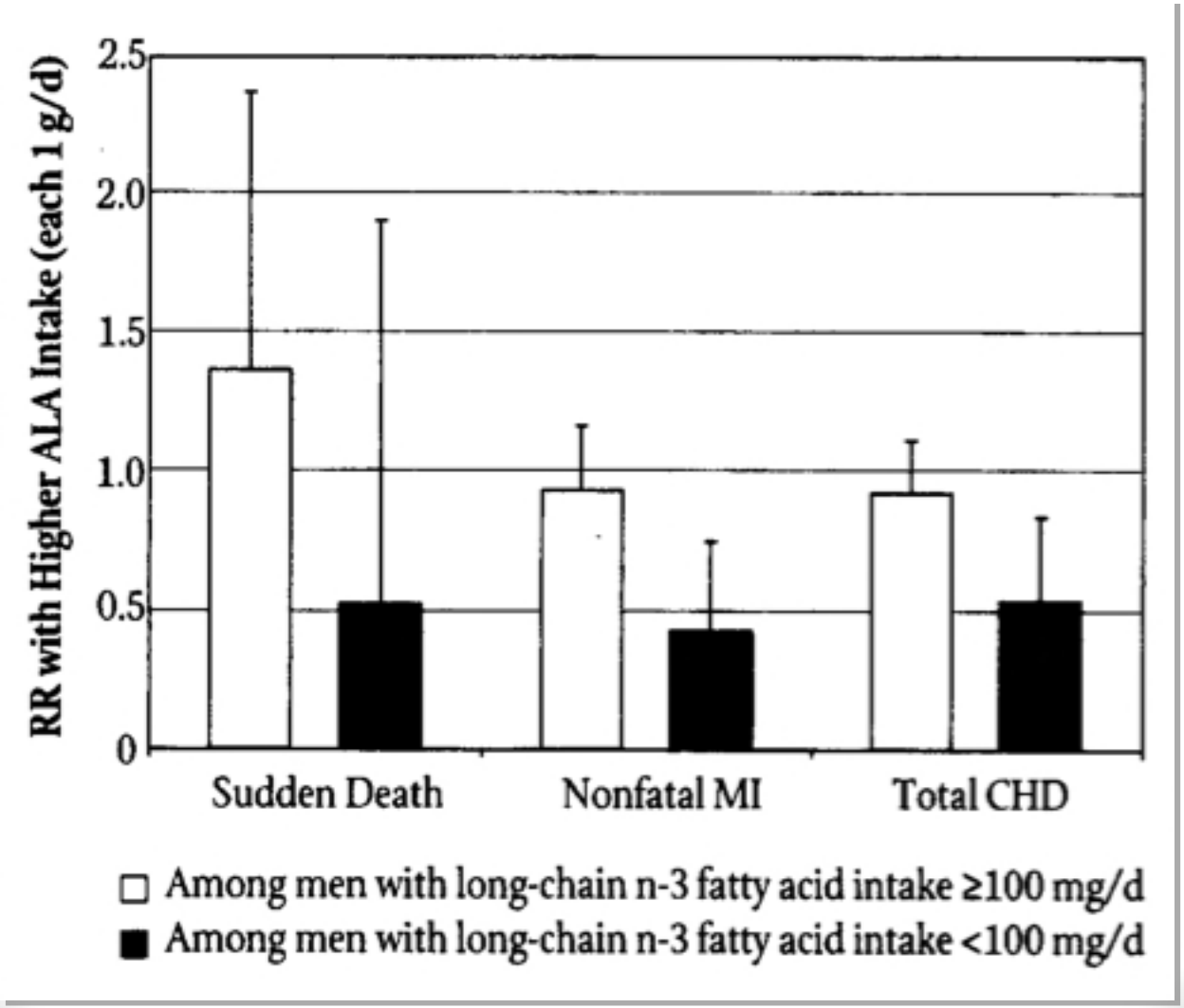
Relative Risk of CHD Associated with Each 1 g/day of High ALA Intake



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Mozaffarian et al., *Altern Ther Health Med* 2005;11:24-30

Alpha Linolenic Acid & Endothelial Dysfunction

	Measurements	Studies	Results
Inflammation	Arachidonic Acid (AA), PGI_2, IL-6, IL-1β, TNF-α, CRP, VCAM-1, ICAM-1, E-Selectin, fibrinogen, Serum Amyloid A (SAA)	Sekine et al., 2007	↓ vascular AA levels, ↑PGI_2 formation
		Zhao et al., 2007	↓ IL-6, IL-1β, and TNF-α production
		Wendland et al., 2006	↓ fibrinogen levels
		Lopez-Garcia et al., 2004	↓ CRP, IL-6, E-Selectin
		Zhao et al., 2004	↓ CRP, VCAM-1, ICAM-1, E-Selectin
		Rallidis et al., 2004	↓ VCAM-1
		Bemelmans et al., 2004	↓ CRP
		Rallidis et al., 2003	↓ CRP, SAA, IL-6

Composition of Canola Oil

Canola Oil

- High in monounsaturated fat
- High in omega-3 fat
- **High in plant sterols**
- Antioxidant vitamin E
- Low in saturated fat
- Other health-promoting constituents

Plant Sterols in the Diet

Average daily plant sterol intake of adults
150 - 400 mg/day

major source:
- fat and oils (~1g/100ml canola oil)
- bread and cereals
- fruits and vegetables
- nuts





Recommended intake of plant sterol-enriched foods for a significant cholesterol-lowering effect
2 g/day

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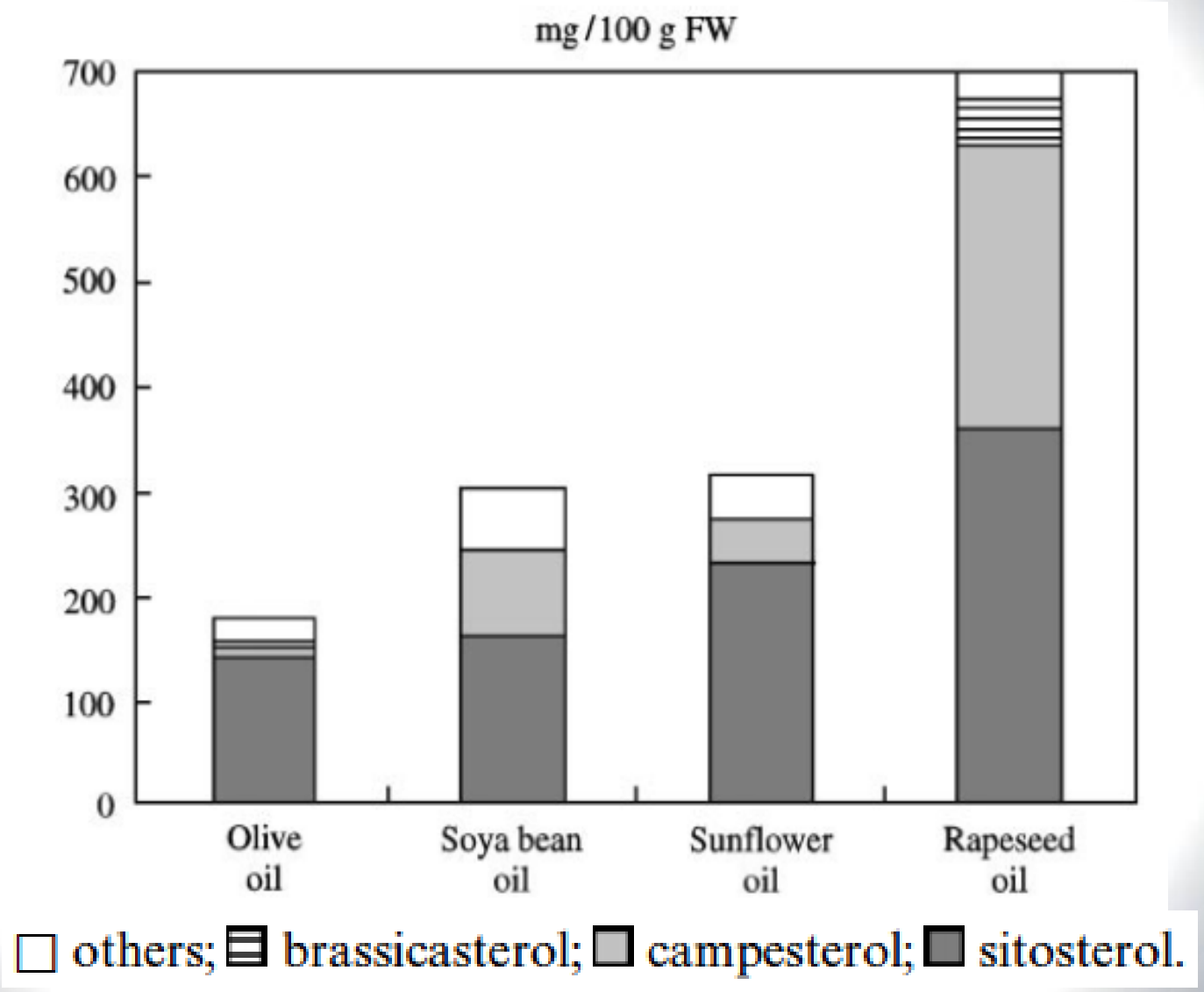
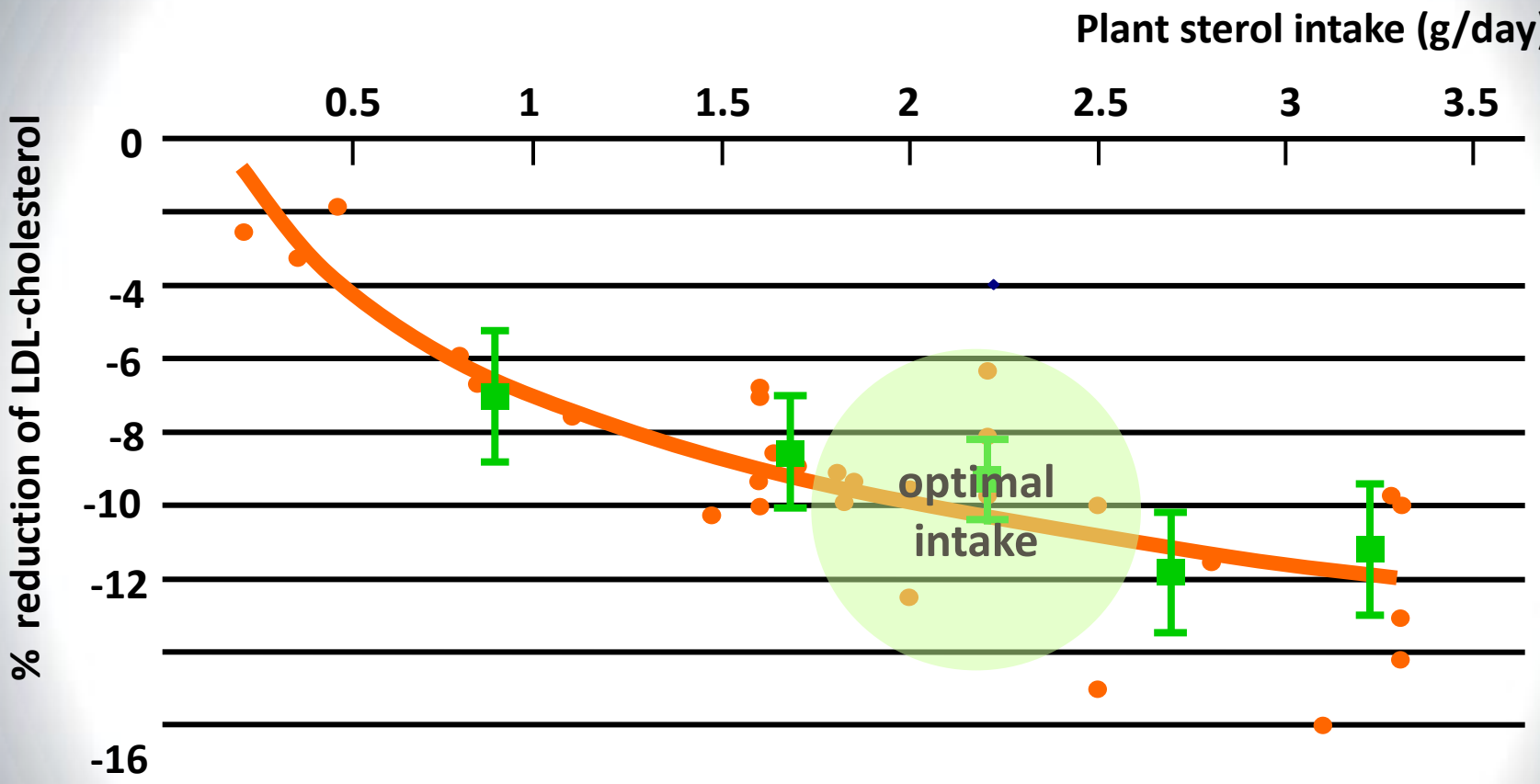
Katan et al., *Mayo Clin Proc* 2003;78:965-78;
National Cholesterol Education Program (NCEP) Expert Panel *JAMA* 2001 May 16;285:2486-97

Plant Sterol Content of Refined Vegetable Oils



Piironen et al., *JFCA* 2000;13:619-24

Cholesterol Lowering with Plant Sterols in Fat-based Foods: Dose-response Relationship



data of ~ 30 placebo-controlled Unilever initiated studies with phytosterol-enriched spreads

data (mean plus 95% confidence interval) from meta-analysis of 41 studies with phytosterols or stanols

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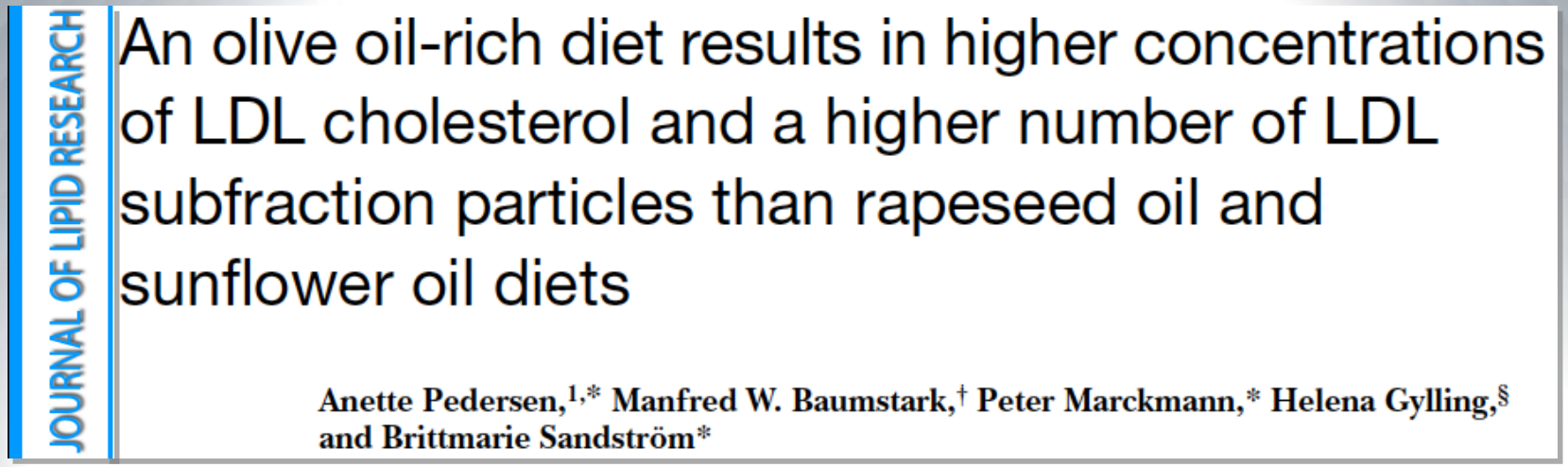
Adapted from: Katan et al., *Mayo Clin Proc*. 2003;78:965-978



Design: Randomized crossover trial; 18 healthy men; 3 week dietary intervention
Diet: Olive oil, rapeseed oil (canola oil), or sunflower oil (50 g oil per 2500 kcal/d)

Results: As compared to the olive oil and sunflower oil diets, the rapeseed oil (canola oil) diet resulted in the most favorable effects on:

- Plasma lipids, including LDL and VLDL
- Lipids ratios, including TC:HDL and LDL:HDL
- Plasma apolipoproteins
- Number and lipid content of LDL subfractions, ie VLDL

"…Some of the differences may be attributed to differences in the squalene and phytosterol contents of the oils".

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Pedersen et al., *J Lipid Res* 2000;41:1901-11

European Journal of Clinical Nutrition (1998) 52, 312–315
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http://www.stockton-press.co.uk/ejcn

Review

Monounsaturated oils do not all have the same effect on plasma cholesterol

AS Truswell and N Choudhury

Human Nutrition Unit, University of Sydney, Sydney, NSW 2006, Australia

…it has been found that olive oil has little to no effect on cholesterol lowering, as compared to other MUFA oils, such as **canola oil** or high-oleic sunflower oil

Truswell & Choudhury. *Eur J Clin Nutr* 1998;52:312-15

Composition of Canola Oil

Canola Oil

- High in monounsaturated fat
- High in omega-3 fat
- High in plant sterols
- **Antioxidant vitamin E**
- Low in saturated fat
- Other health-promoting constituents

Canola Oil Contains Vitamin E

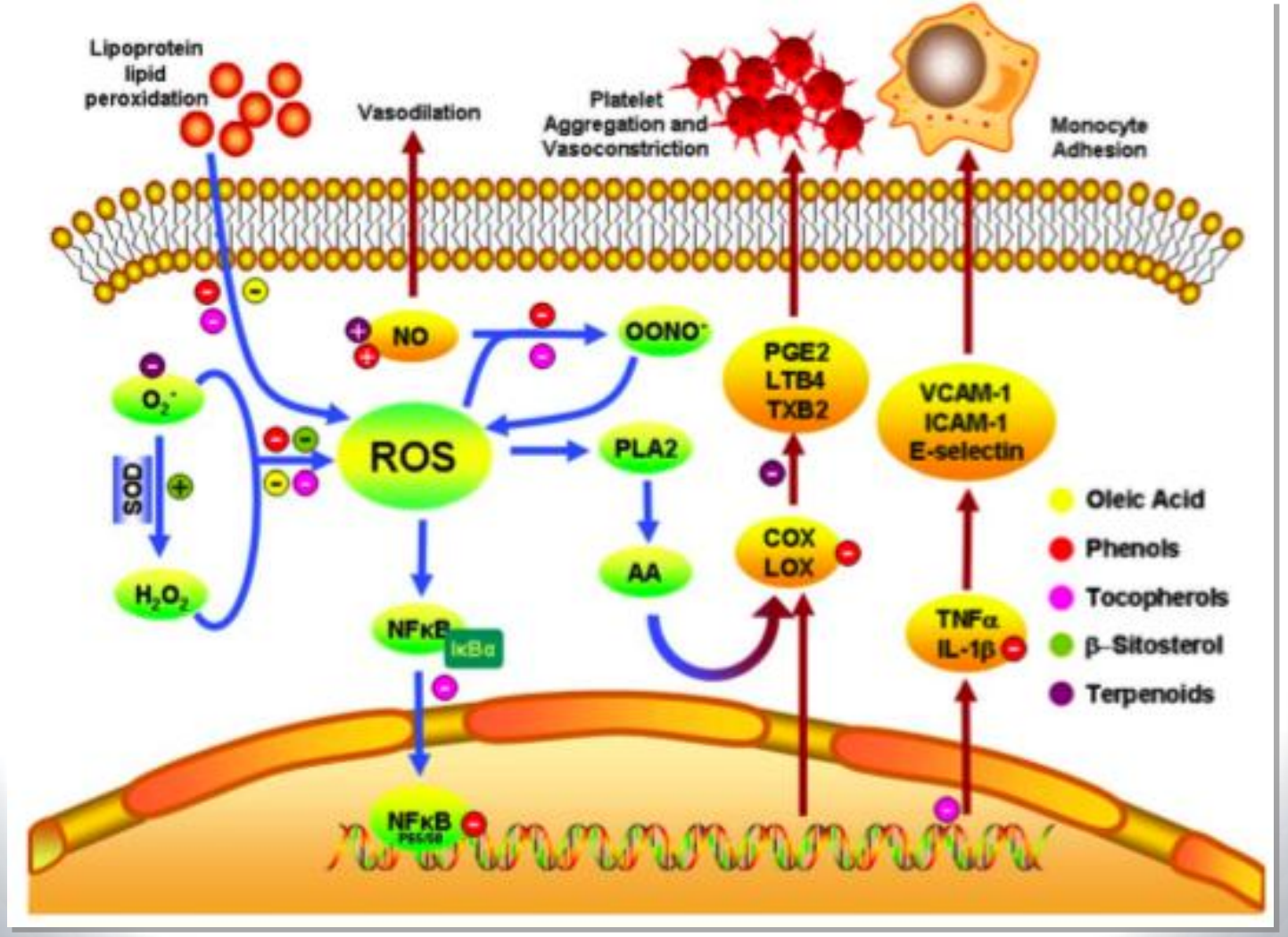
1 Tbsp. of Canola Oil provides ~2.9 mg of Vitamin E

- equivalent to ~1/5 of the recommended daily intake for adults (15 mg ATE*).

Vitamin E present in canola oil could be beneficial in the prevention and treatment of diseases related to oxidative stress including cancer, cardiovascular and neurodegenerative disorders

Giugliano. *Nutr Metab Cardiovasc Dis* 2000;10:38-44;
Practico & Delanty. *Am J Med* 2000;109:577-85

Endothelial Function:
Proposed Mechanisms of Action of Oleic Acid and Other Minor Compounds from Vegetable Oils



Perona et al., *J Nutr Biochem* 2006;17:429-45

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Canola and flax oils in modulation of plasma lipids, vascular function and biomarkers of cardiovascular disease risk; Randomized crossover controlled trials

Canola & Flax; Clinical Trial 1

- Sept 2007 – 2010
- Richardson Centre (RCFFN) at Univ. of Manitoba
- 3 treatments (4 weeks)
  - High-oleic Canola Oil
  - HOCO/Flaxseed Oil blend
  - Average American Diet (control)
- 36 hyperlipidemic subjects
- Clinical trial complete
- Analysis in progress

Canola & Flax; Clinical Trial 2

- Sept 2010 – 2012
- Multi-Centre Trial
  - RCFFN (Univ. of Manitoba), Univ. of Toronto, Laval Univ., & Penn State Univ.
- 5 treatments (4 weeks)
  - Canola oil
  - DHA enriched canola oil
  - High-oleic acid canola oil
  - Flax oil
  - Corn oil (control)
- 140 subjects (35 per site)

Clinical Trial Endpoint Analysis

- **Endothelial health and body composition**
  - Flow-mediated dilation (by Endo-PAT2000)
  - Body fat deposition by DEXA
- **Plasma lipids and lipoproteins, inflammatory, & peroxidation biomarkers**
  - TC, HDL-C, LDL-C, and TG, lipoprotein subclasses
  - CRP, IL-6, IL-10, sTNFRα, sVCAM-1, sICAM-1, E-selectin
  - Urinary isoprostanes and prostaglandins
- **ALA conversion to long chain n-3 fatty acids**
  - [U-13C] alpha-linolenic acid (70mg dose)
  - FADS1/FADS2 mRNA and protein expression
  - Genetic analyses of FADS1 and FADS2

Summary

- Canola oil contains several constituents that reduce risk of cardiovascular disease and other chronic disorders

- The monounsaturated fat content of canola is associated with favorable modulation of lipid levels, blood pressure, insulin sensitivity, as well as oxidative and inflammatory status

- The omega-3 content of canola is predicted to exert desirable changes in cardiovascular risk, associated with beneficial effects on endothelial function and numerous other health-related parameters

Summary cont..

- Plant sterols in canola oil further contribute to the reduction in LDL-C levels
- Additional bioactives in canola oil may exert positive biological effects on health, such as vitamin E
- Clinical studies on canola oil are currently being conducted to substantiate the cardioprotective benefits of canola oil

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Thank you

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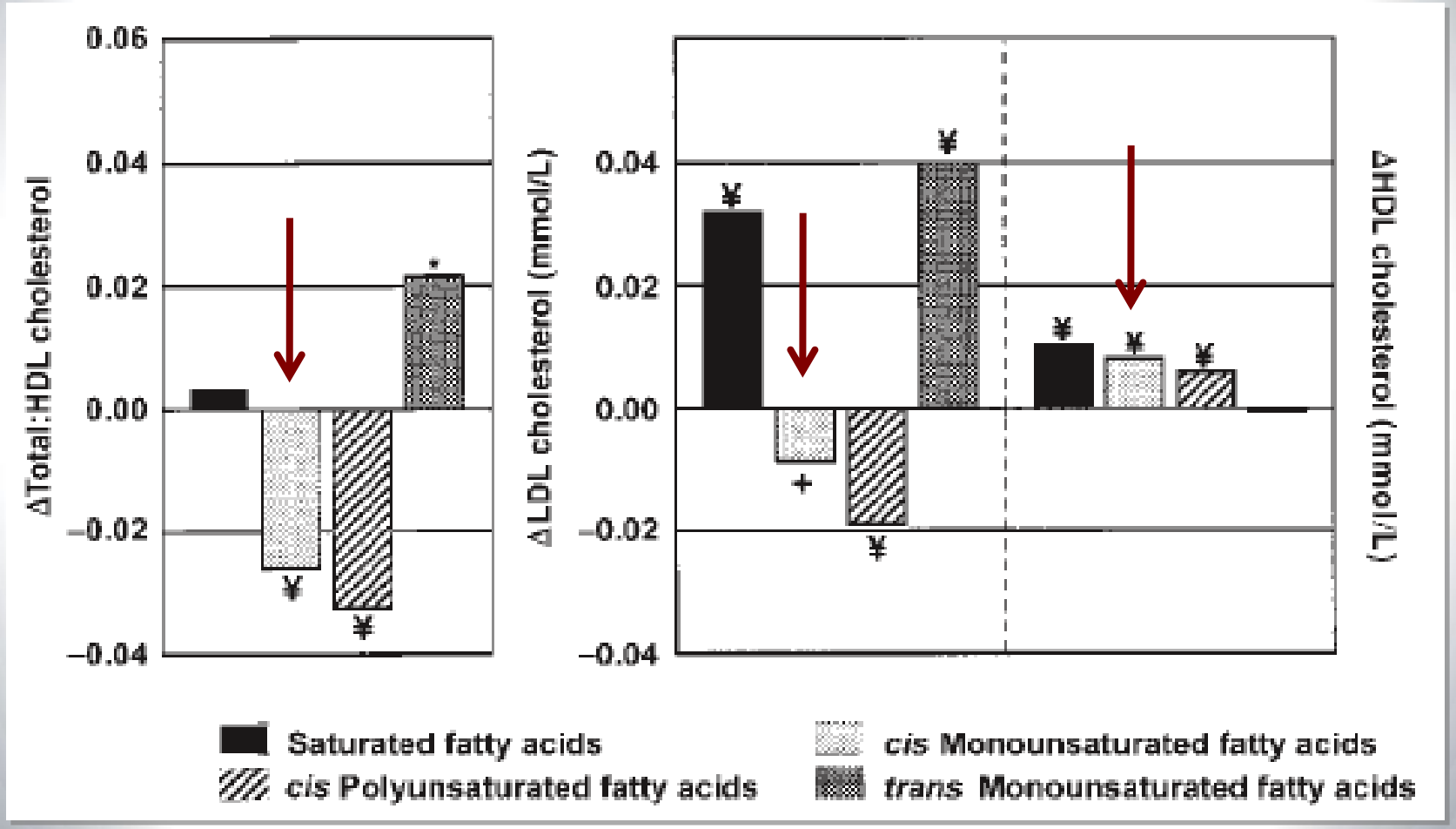
APPENDIX

Supplemental Material

MUFAs & Blood Lipids

Effects of dietary fatty acids on serum lipids: A meta-analysis of 60 controlled trials



1% isocaloric replacement of CHO (P*<0.05; +*P*<0.01; ¥*P*<0.001)**

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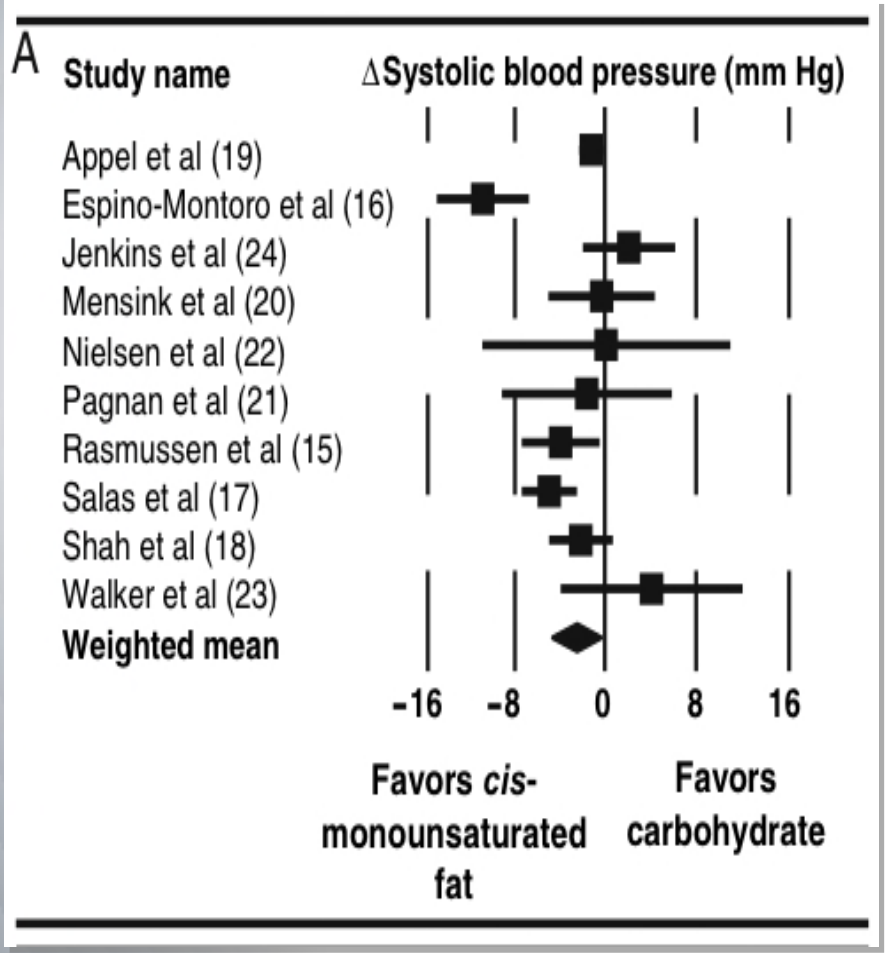
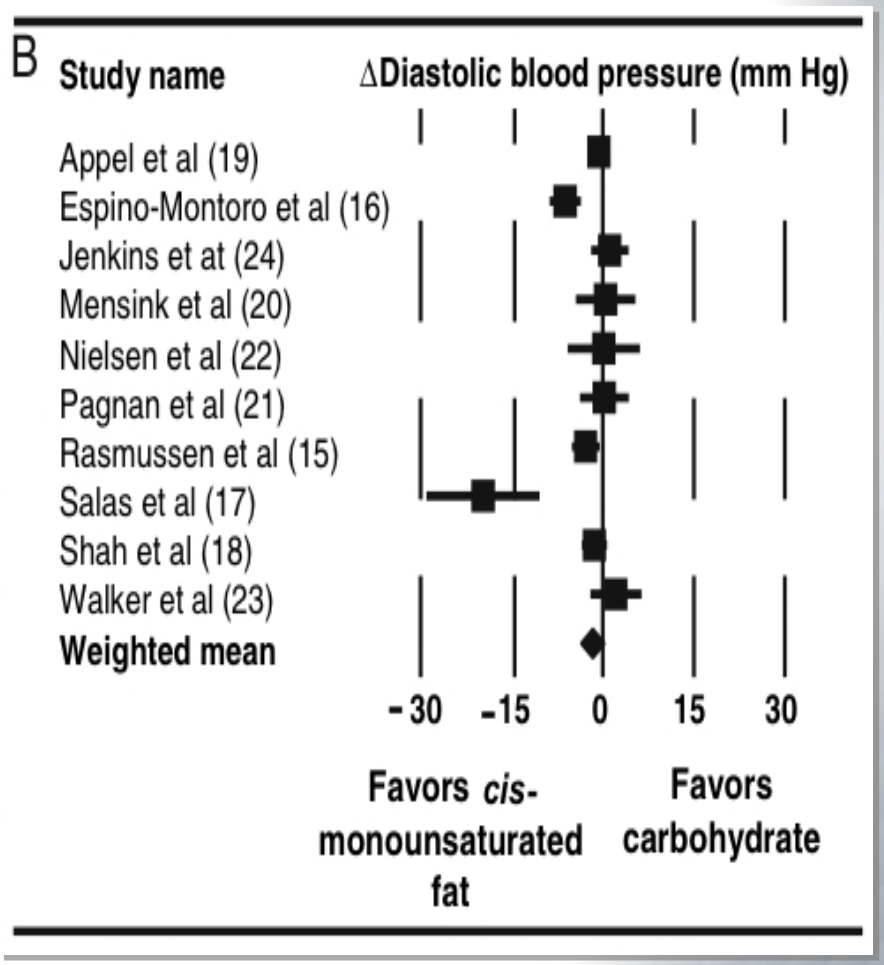
Mensink RP et al., *Am J Clin Nutr* 2003;77:1146-55

MUFAs & Blood Pressure

Effect of high-CHO or high-*cis*-MUFA fat diets on blood pressure: A meta-analysis of interventions trials





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Shah et al., *Am J Clin Nutr* 2007;85:1251-6

Effects of MUFA on LDL Oxidative Status

Reference	Subject	Design/duration	Diets	Outcome (MUFA vs. other diets)
Moreno et al. 2008	Healthy men (n=20)	Randomized,CO 4 weeks	MUFA SFA H-CHO	↑ OxLDL lag time ↑ propagation rate ↓ oxLDL macrophage uptake
Ahuja et al. 2003	Healthy sbj (n=31)	Randomized, CO 14-16 days	MUFA H-CHO	↑ OxLDL lag time
Nielsen et al. 2002	Healthy sbj (n=18)	Randomized, CO 3 weeks	MUFA n-3 PUFA* n-6 PUFA	↑ OxLDL lag time ↓ propagation rate with MUFA and n-3 PUFA vs. PUFA
Hargrove et al. 2001	Healthy sbj (n=20)	Randomized, CO 3.5 weeks	AAD NCEP 3 MUFA diets	↑ OxLDL lag time ↓ rate of OxLDL
Ashton et al. 2001	Healthy sbj (n=28)	Randomized, CO 1 month	MUFA H-CHO	↑ OxLDL lag time ↓ rate of oxidation ↓ conjugated dienes
Baroni et al. 1999	HC patients (n=13)	CO 8 weeks	MUFA PUFA	↑ OxLDL lag time

*canola oil

MUFA & Endothelial Dysfunction

	Measurements	Studies	Results
Inflammation & Hemostasis	**Acute Phase Reactants:** • CRP, Fibrinogen **Cytokines:** • IL-6, TNF-α **Adhesion Molecules:** • VCAM-I, ICAM-I, E-selectin **Coagulation and Fibrinolysis Factors:** • Tissue factor, Factor VIIc, TXB_2, LTB_4, PAI-1, Platelet aggregation **Others:** • NF-κB, Plasma antioxidant capacity (PAC)	Mena et al., 2009 Pacheco et al., 2008 Bogani et al., 2007 Brunelleschi et al., 2007 Pacheco et al., 2006 Serrano-Martinez et al., 2005 Visioli et al., 2005 Allman-Farinelli et al., 2005 Smith et al., 2003* Kwon et al., 1991*	↓ IL-6, ICAM-I, VCAM-I & CRP ↓ post-prandial AUC for ICAM-I & VCAM-I ↓ TXB_2 & LTB_4, ↑ PAC ↓ NF-κB translocation ↓tissue factor, fibrinogen, PAI-1 ↓ TNF-α & VCAM-I ↓ TXB_2 & ↑ PAC ↓ factor VIIc ↓ platelet aggregation & ↓ factor VIIc ↓ AA & platelet aggregation

*canola oil

MUFA Effects on Insulin & Glucose Responses

Reference	Subject (sbj)	Design/duration	Diets	Outcome (MUFA vs. other diets)
Due et al. 2008	Obese sbj (n=46)	Randomized, PAR 6 months	MUFA SFA Low-fat	↓ HOMA-IR ↓ fasting glucose, insulin
Lopez et al. 2008	Healthy men (n=14)	Randomized, CO Single meal	4 diets varying in MUFA:SFA	↑ postprandial β-cell function and insulin sensitivity with ↑ in MUFA:SFA of diet
Shah et al. 2007	T2DM Subjects (n=11)	Randomized, CO Single meal	SFA MUFA n-6 PUFA EPA+DHA	↓ postprandial insulin response vs. SFA and n-6 PUFA ↔ postprandial glucose response
Paniagua et al. 2007	Obese T2DM (n=11)	Randomized, CO 28 days	SFA MUFA H-CHO	↑ insulin sensitivity ↓ fasting glucose ↑ postprandial GLP-1
Vessby et al. 2001	Healthy sbj (n=162)	Randomized 3 months	SFA MUFA	↑ insulin sensitivity
Joannic et al. 1997	Healthy sbj (n=8)	Randomized, CO Single meal	**MUFA*** n-6 PUFA	↑postprandial glucose and insulin responses

Abbreviations: CO, crossover; PAR, parallel arm; T2DM Type 2 Diabetes Mellitus; GLP-1, glucagon-like peptide-1

***canola and sunflower oil blend**

MUFAs & Insulin Sensitivity

Substituting dietary SFA for MUFA impairs insulin sensitivity in health men and women: The KANWU study

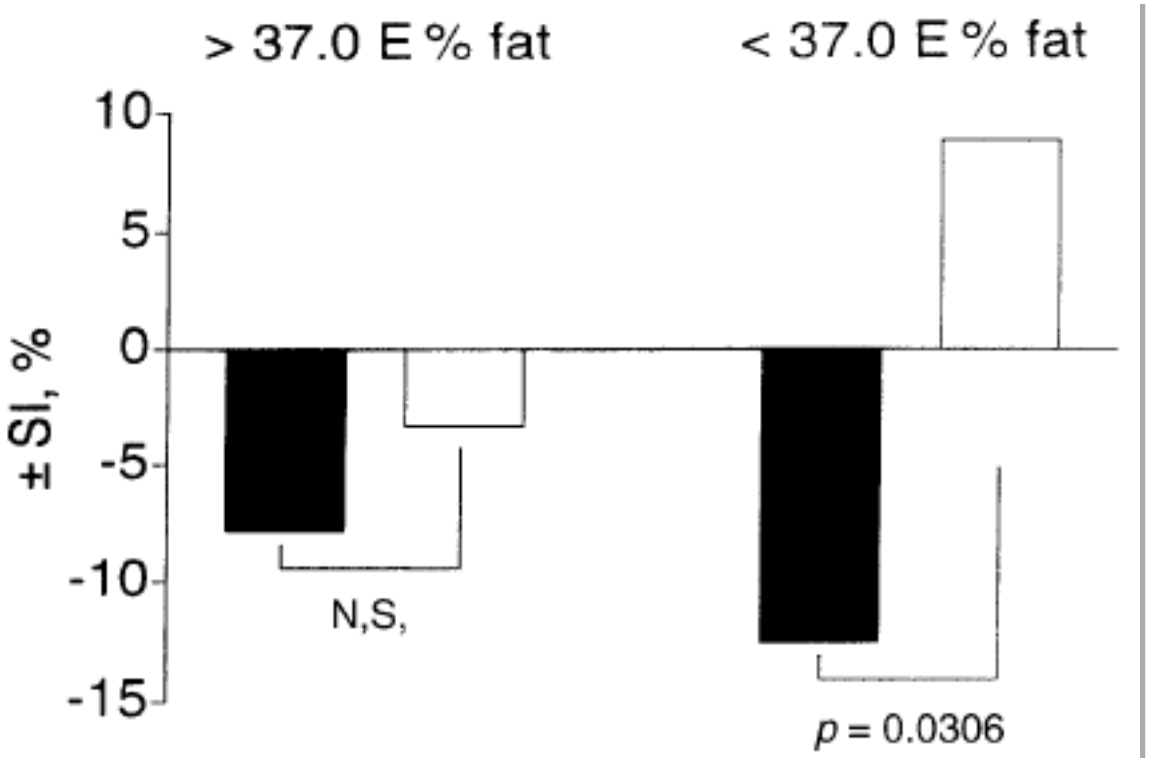

Fig. 1. Effects of a change of dietary fat quality on insulin sensitivity when related to total dietary fat intake during treatment

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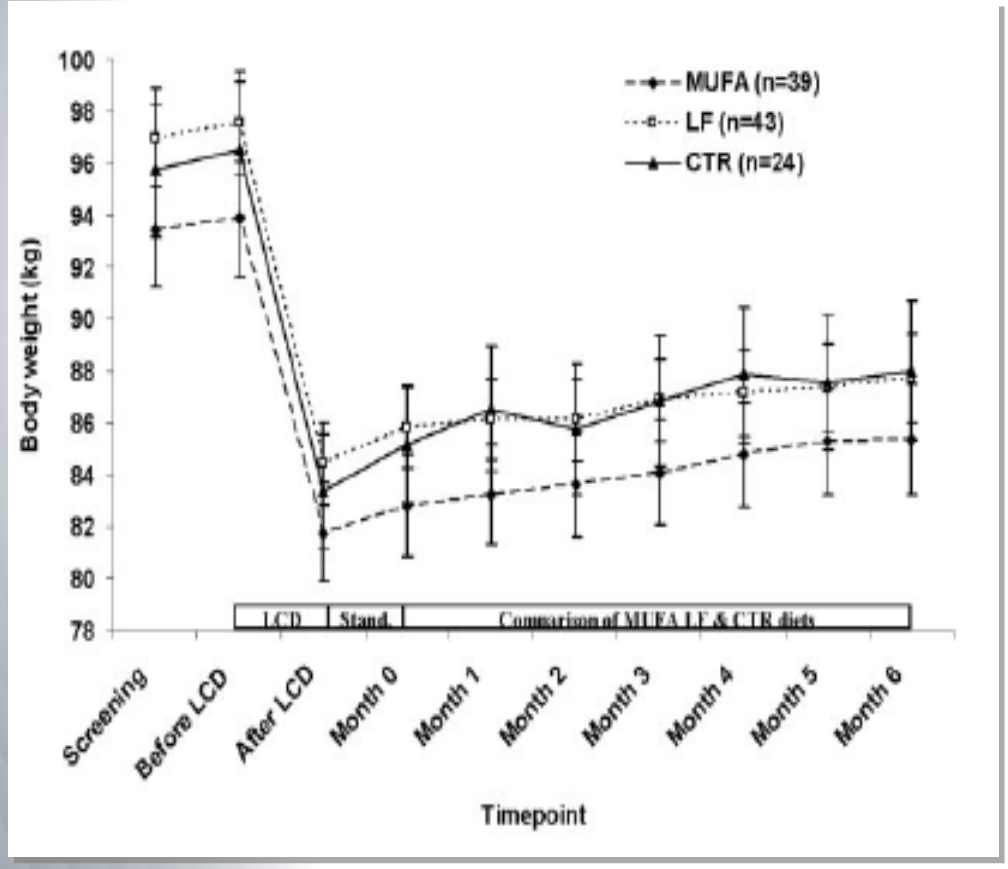
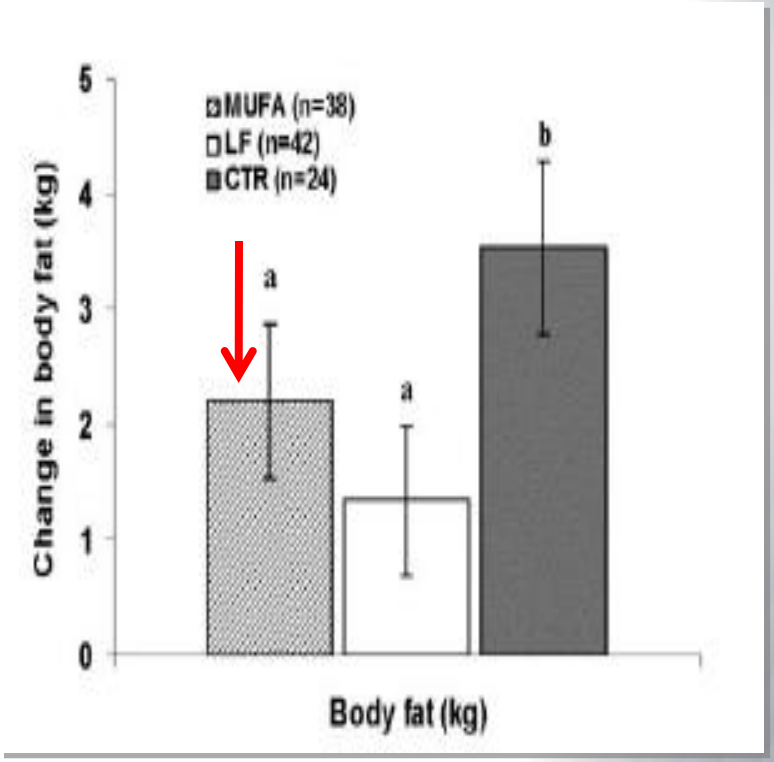
Vessby et al., *Diabetologia* 2001;44:312-19

MUFAs & Weight Management

Change in Body Weight and Body Fat at Baseline and 6 Months: Effects of MUFA, Low Fat, & Control Fat Diets





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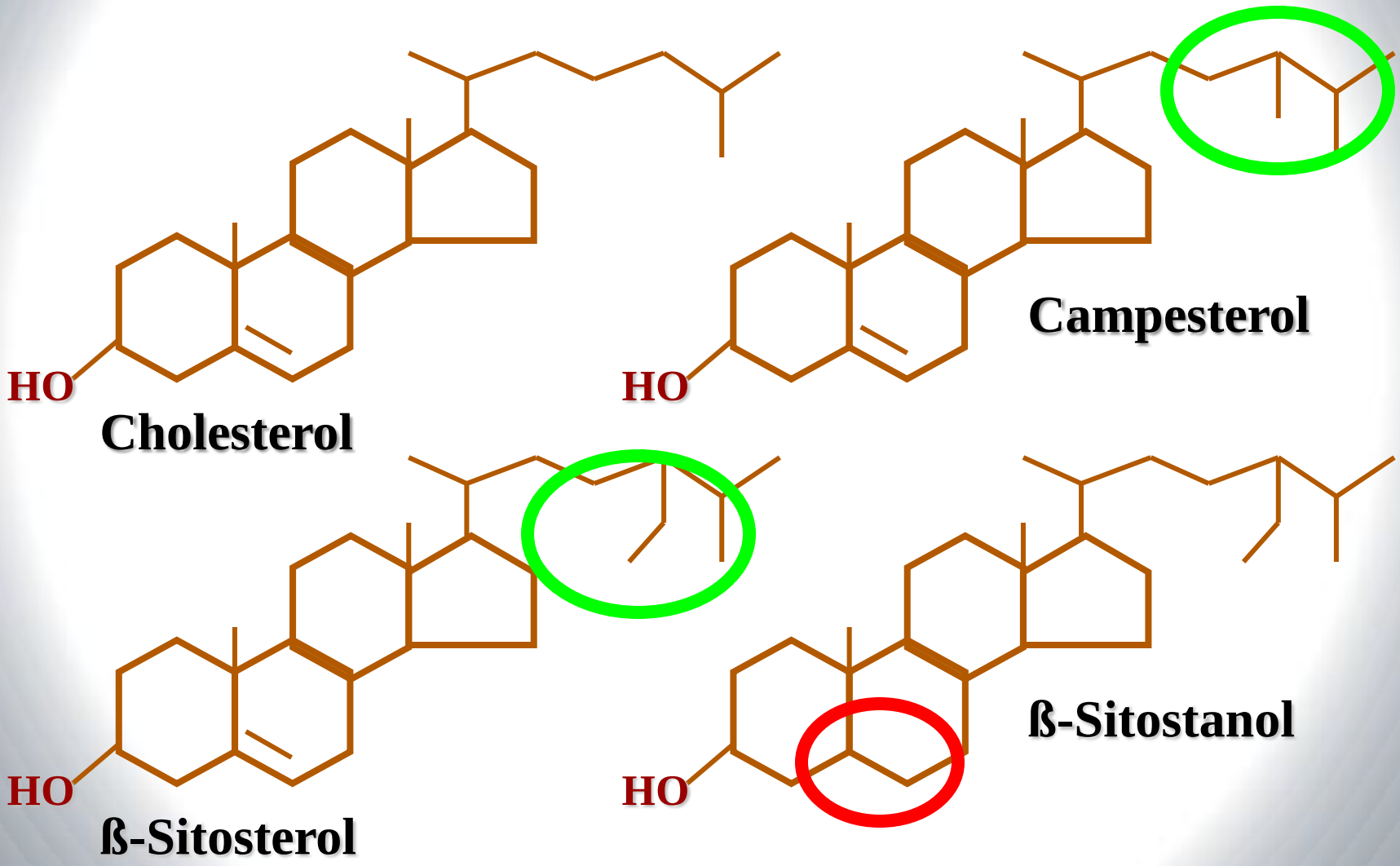
Due et al., *Am J Clin Nutr* 2008;88:1232-41

Structure of cholesterol and major plant sterols and stanols



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Cholesterol-lowering effect of plant sterols: mechanism of action

Intake of 2 g plant sterols/day → 30-40% reduction in cholesterol absorption