The Current Status and Nutritional Attributes of Palm Oil

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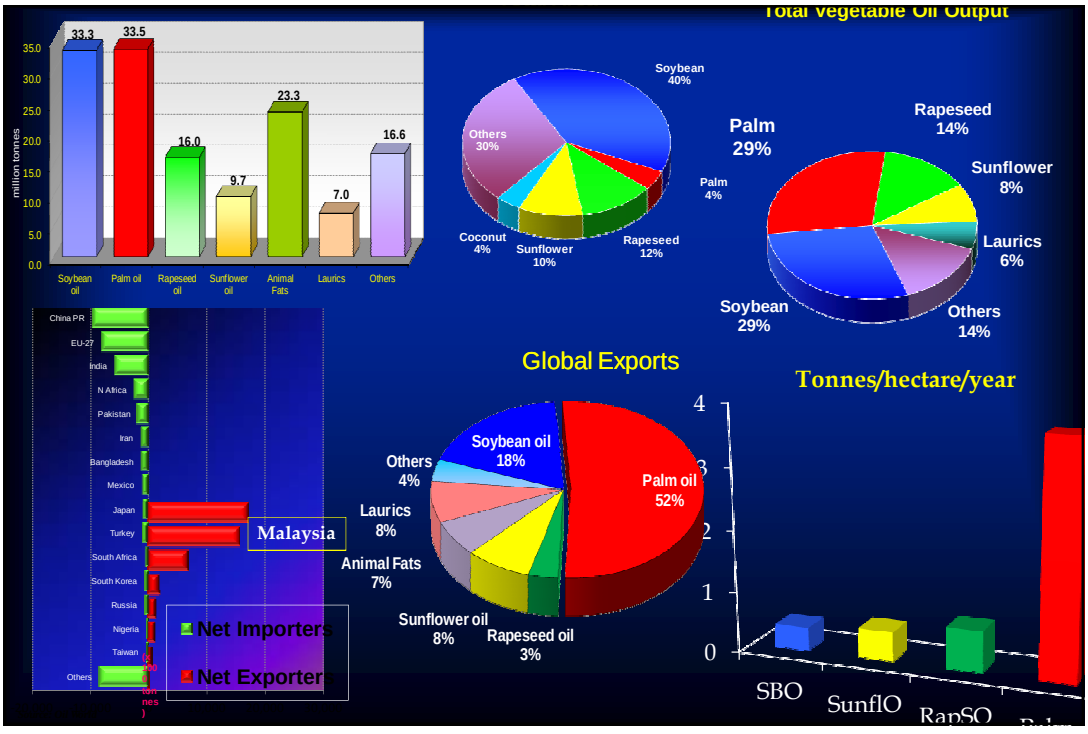


"Vitamin A" activity of red palm oil

	RE Per 100 g	Relative quality (Times <red palm oil
Red Palm Oil	30,000	-
Carrots	2,000	15
Leafy Vegetables	685	44
Apricots	250	120
Tomatoes	100	300
Bananas	30	1000
Orange Juice	8	3,750

Phytoene	2.0%
Phytofluene	1.2%
Cis-β- Carotene	0.8%
β – Carotene	47.4%
α- Carotene	37.0%
Cis- α- Carotene	6.9%
ζ- Carotene	1.3%
δ - Carotene	0.6%
γ - Carotene	0.5%
Neurosporene	Tr
β - Zeacarotene	0.5%
α - Zeacarotene	0.3%
Lycopene	1.5%

Numerous human studies showing efficacy of red palm oil in fighting Vitamin A deficiency

...studies have adopted different methods to provide Vitamin A naturally

- Children fed traditional Indian sweets made with redPO
- School children fed biscuits baked with redPO
- School children given 5 – 10 mL redPO daily
- Cooking green leafy vegetables in redPO

- Also Vitamin A status improved by feeding redPO to pregnant mothers at various stages of pregnancy.

- Also lactating mothers

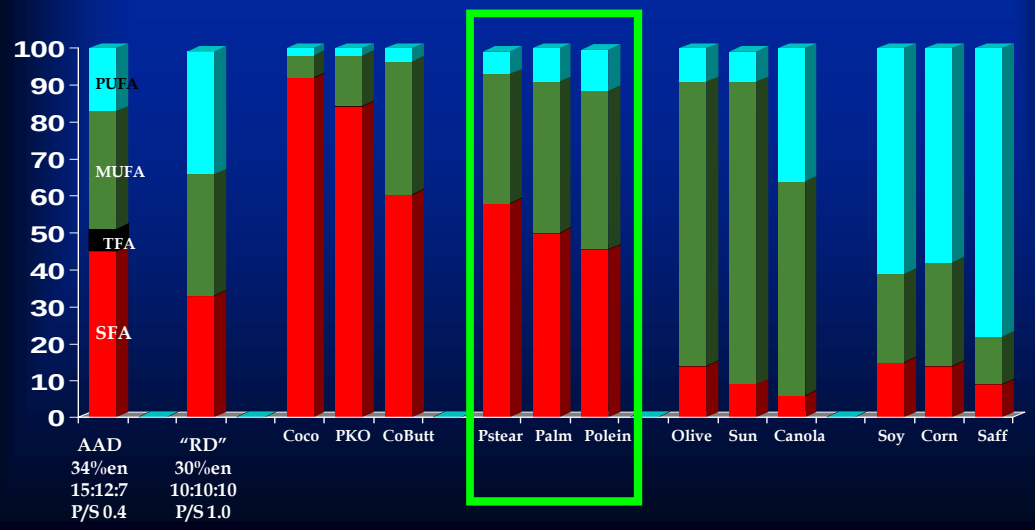
Numerous human studies showing efficacy of red palm oil in fighting Vitamin A deficiency

Comparison of Vitamin E Content of red palm oil & other Vegetable Oils

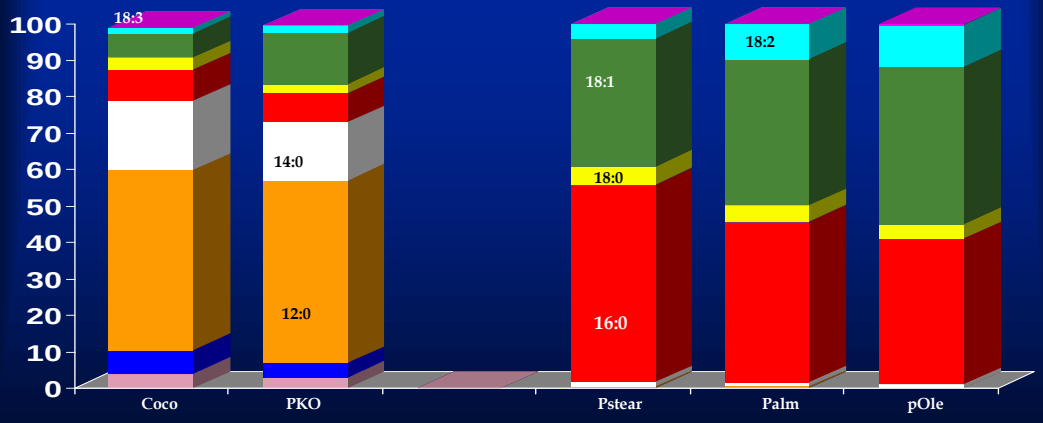
Oil	Tocopherols(ppm) αT	βT	γT	δT	Tocotrienols(ppm) αT3	βT3	γT3	δT3	Ppm T+T3
Red Palm Oil	152	-	-	-	205	-	439	94	890
Soyabean	101	-	593	264					985
Cornoil	112	50	602	18					782
Groundnut	130	-	216	21					367
Safflower	387	-	174	240					801
Sunflower	487	-	51	8					546

Numerous in vitro studies showing efficacy of tocotrienols in inhibiting breast cancer cell proliferation and decreasing neurodegeneration

Dietary fat composition: by fatty acid classes



Palm Oil is distinct from Palm Kernel Oil



RISK FACTORS FOR CHD

- Gender
- Increasing age
- Genetics: Family history of CHD

- High TC, LDL-C
- Low HDL-C
- Smoking
- Diabetes
- Obesity

DIET

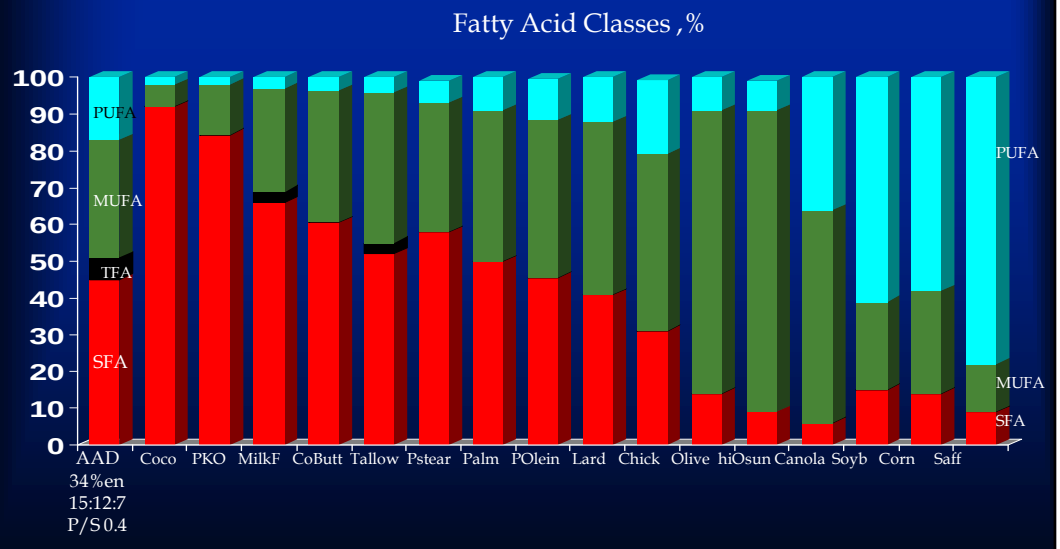
- Fat quality
- Protein quality
- Fiber
- Antioxidants
- Phytochemicals
- Carbohydrate type
- Alcohol

Risk calculator

DIETARY FATS, PLASMA LIPOPROTEINS & CHD

- Epidemiological studies: positive association between plasma cholesterol and CHD risk
- Plasma cholesterol comprises the cholesterol transported in lipoproteins - VLDL, LDL and HDL
- Plasma cholesterol affected by dietary fat - quality
- Classes of fats (fatty acids)- SATS, MONOS & POLYS
- Major dietary fatty acids: Lauric, Myristic, Palmitic, Stearic, Oleic, Linoleic and Linolenic (12:0, 14:0, 16:0, 18:0, 18:1, 18:2, 18:3)
- Fatty acids have distinct effects on plasma lipoproteins - VLDL, LDL & HDL
- Aim therefore to modulate dietary fatty acid intake - lower LDL and raise HDL →lower CHD risk

Dietary fat composition: by fatty acid classes



Evolution of regression equations predicting the effects of dietary fatty acid *classes* on serum cholesterol

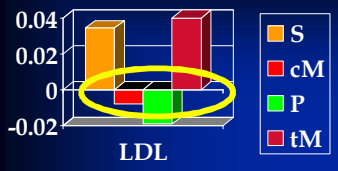
Eqn 1 :	$\Delta SC = 2.74\Delta S - 1.31\Delta P$	(Keys et. al., 1957)
	$\Delta SC = 2.40\Delta S - 1.20\Delta P + 1.5\Delta C1/2$	(Keys et. al., 1965)
Eqn 2 :	$\Delta SC = 2.16\Delta S - 1.65\Delta P + 0.065\Delta C$	(Hegsted et. al., 1965)
	$\Delta SC = 2.74\Delta S - 1.83\Delta P + 0.071\Delta C$	
Eqn 3 :	$\Delta SC = 2.16\Delta S - 0.12\Delta Mb - 0.60\Delta P$	(Mensink & Katan, 1992)
Eqn 4 :	$\Delta SC = 2.10\Delta S - 1.16\Delta P + 0.067\Delta C$	(Hegsted et. al., 1993)
Eqn 5 :	$\Delta SC = 2.02\Delta S - 0.48\Delta M - 0.96\Delta P$	(Yu et. al., 1995)
Eqn 6 :	$\Delta SC = 1.90\Delta S - 0.90\Delta P + 0.021\Delta C$	(Howell et. al., 1997)

ΔSC denotes the change in serum cholesterol in mg/dL, ΔS denotes changes in %en for all the SFA, ΔS denotes changes in %en for the 12-16 carbon SFA

..but serum cholesterol masks underlying differences in lipoprotein cholesterol

- Lipoprotein cholesterol comprises cholesterol in LDL and HDL
- Increased LDL-C a risk factor
- While increased HDL-C is protective
- Ratio of LDL-C/HDL-C or TC/HDL-C far better predictor

So what are the effects of fatty acids classes on lipoprotein cholesterol?



Threshold hypothesis

- 14:0 and 18:2 key factors
- 14:0 raises TC (linear), 18:2 lowers TC (non-linear)
- Threshold level of 18:2 (5-6% en?)
- 16:0 becomes important as LDLr activity decreased

(Hayes & Khosla, (1992), FASEB J., 6, 2600-2607)

- More extensive analyses in gerbils (>50 diets)
- Confirmed 14:0 and 18:2 key factors
- Threshold level of 18:2 (4-5% en?)
- 16:0 cholesterolemic with increasing depression of LDL receptors

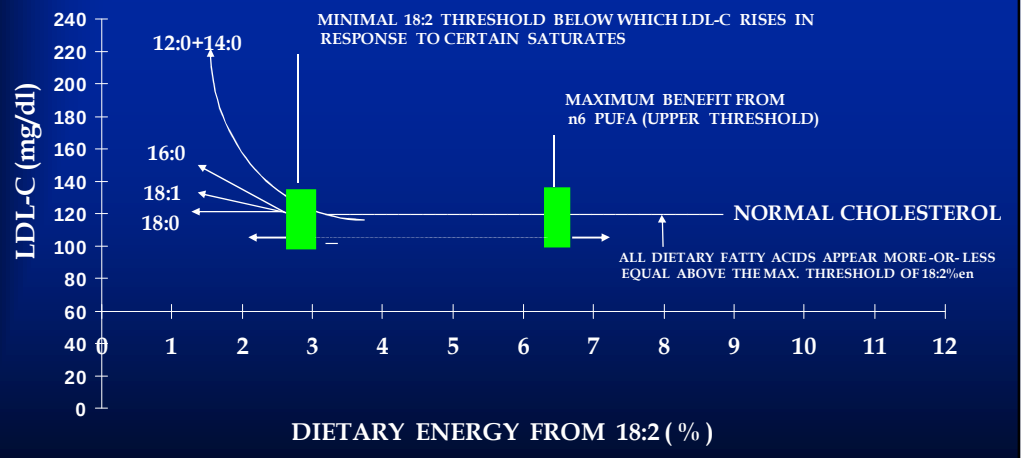
(Pronczuk, Khosla & Hayes, (1994), FASEB J., 8, 1191-1200)

- Similar story in hamsters

(Hayes, Pronczuk & Khosla, (1995), J. Nutr. Biochem., 6, 188-194)

Problem –is not the presence of SFA *per se* – rather it is the *absence* of PUFA

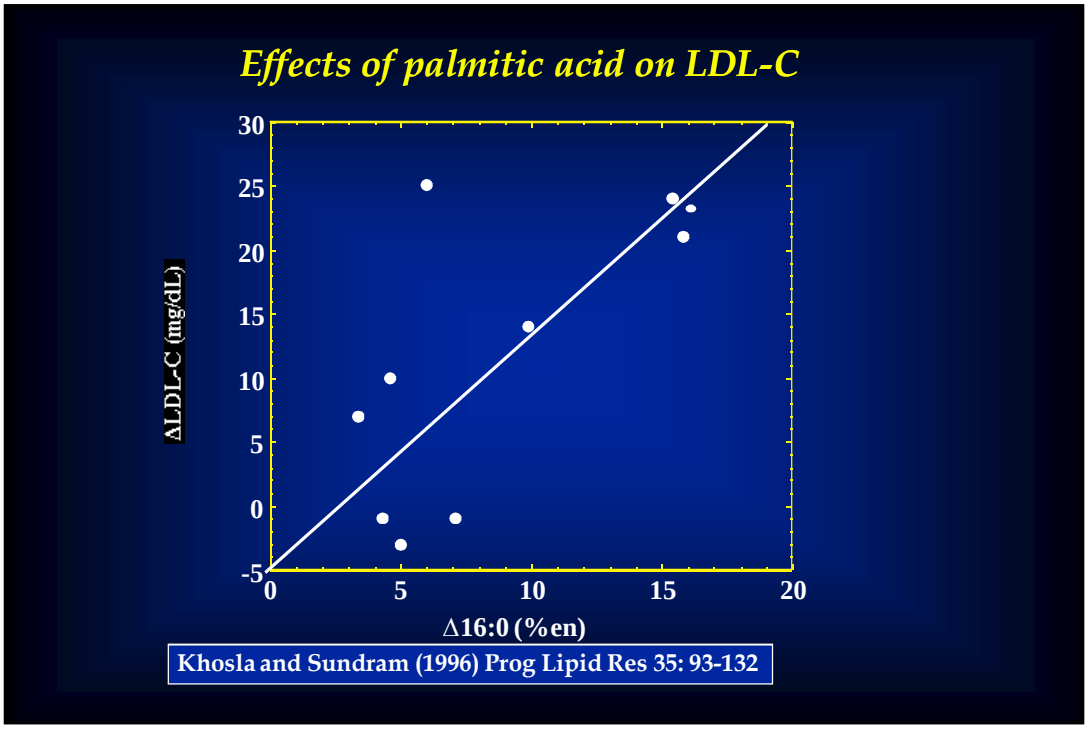
PUTATIVE RELATIONSHIP BETWEEN THE DIETARY 18:2 THRESHOLD AND LDL-C IN HUMANS

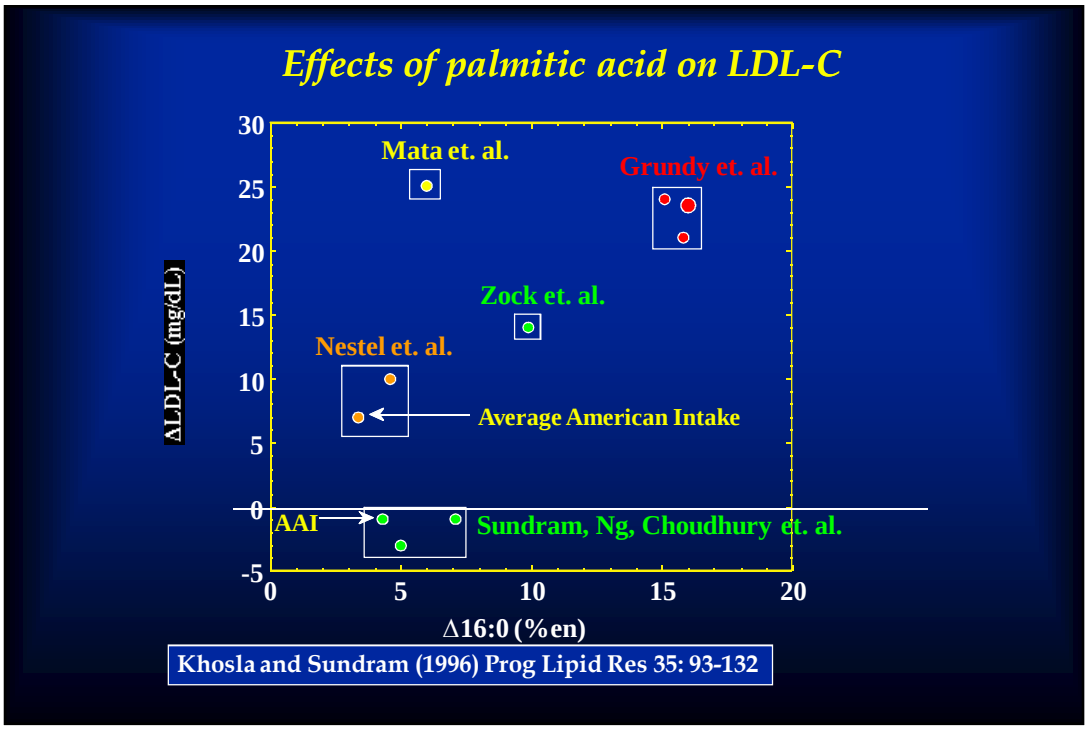


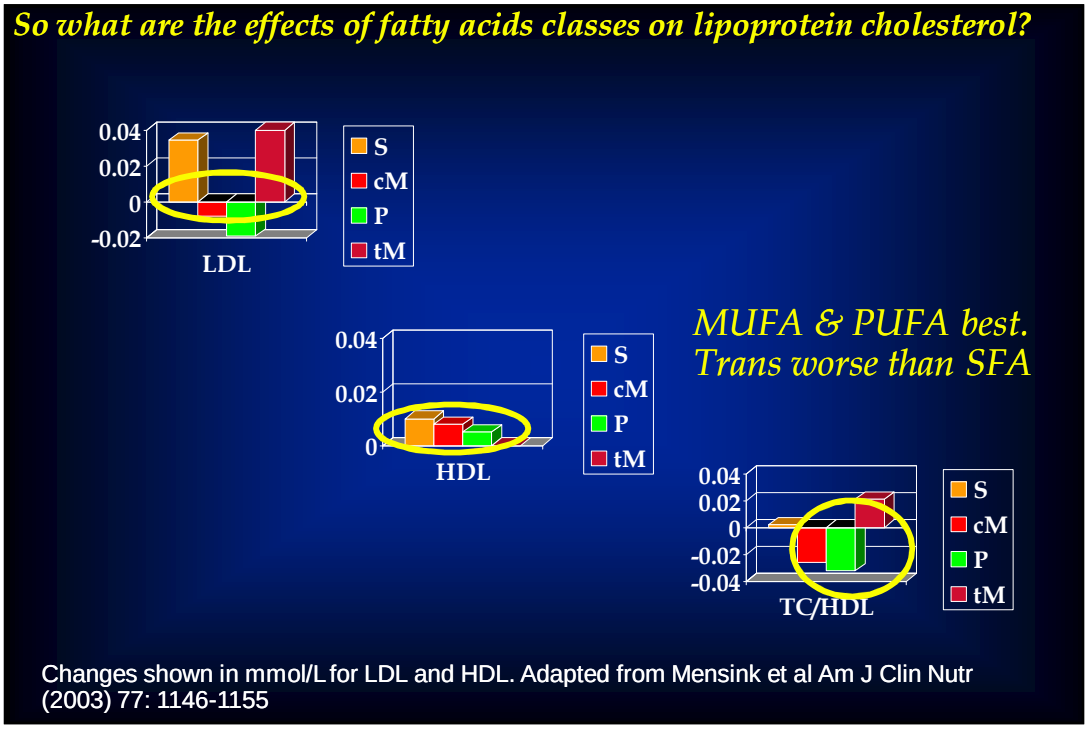
Hayes and Khosla, 1992

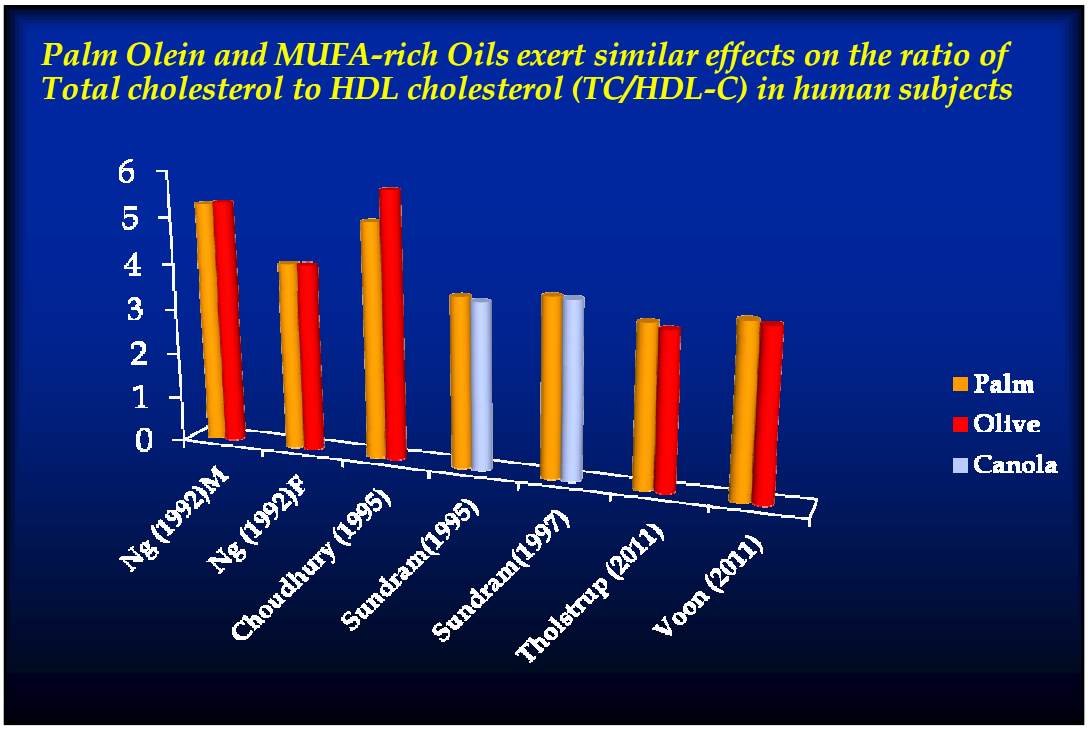
So can make the case.....

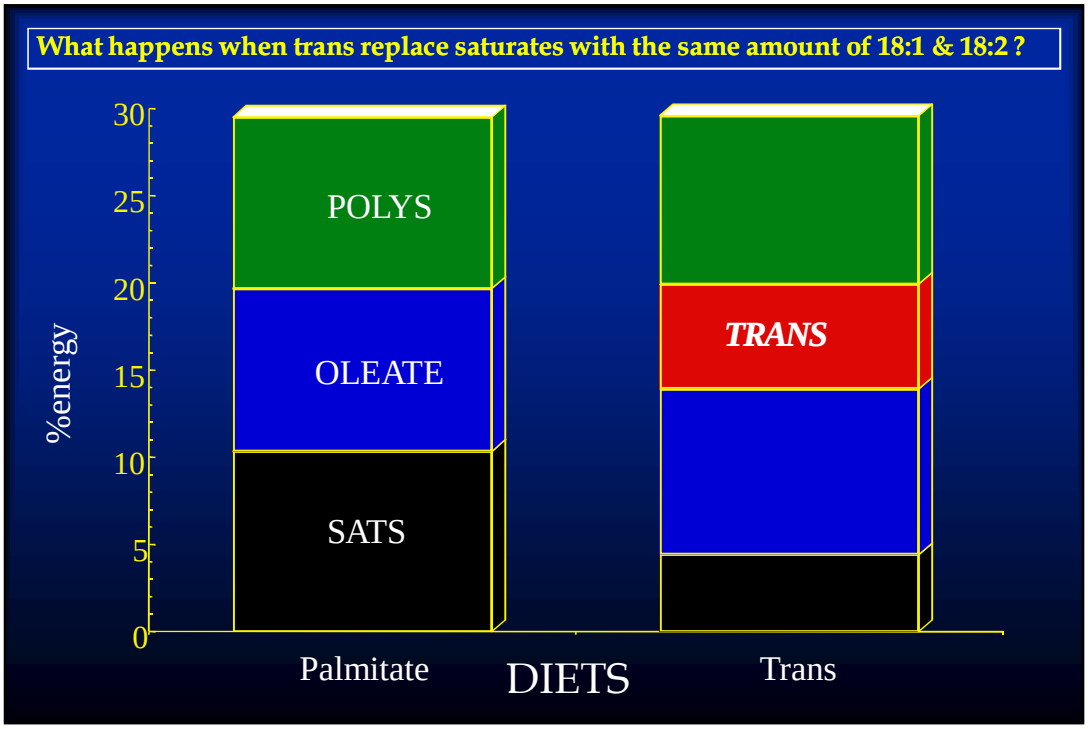
- Palmitic is "conditionally" hypercholesterolemic
- Will raise blood cholesterol if consumed in the presence of too little linoleic acid but is "neutral" with adequate linoleic acid in diet (threshold hypothesis)
- OK – in normocholesterolemics consuming moderate total fat (~30% calories), with adequate linoleic acid (~5-6% calories)
- Agreement comes from several studies from Canada, Australia, Malaysia,China, India and US – but none of these are metabolic ward studies

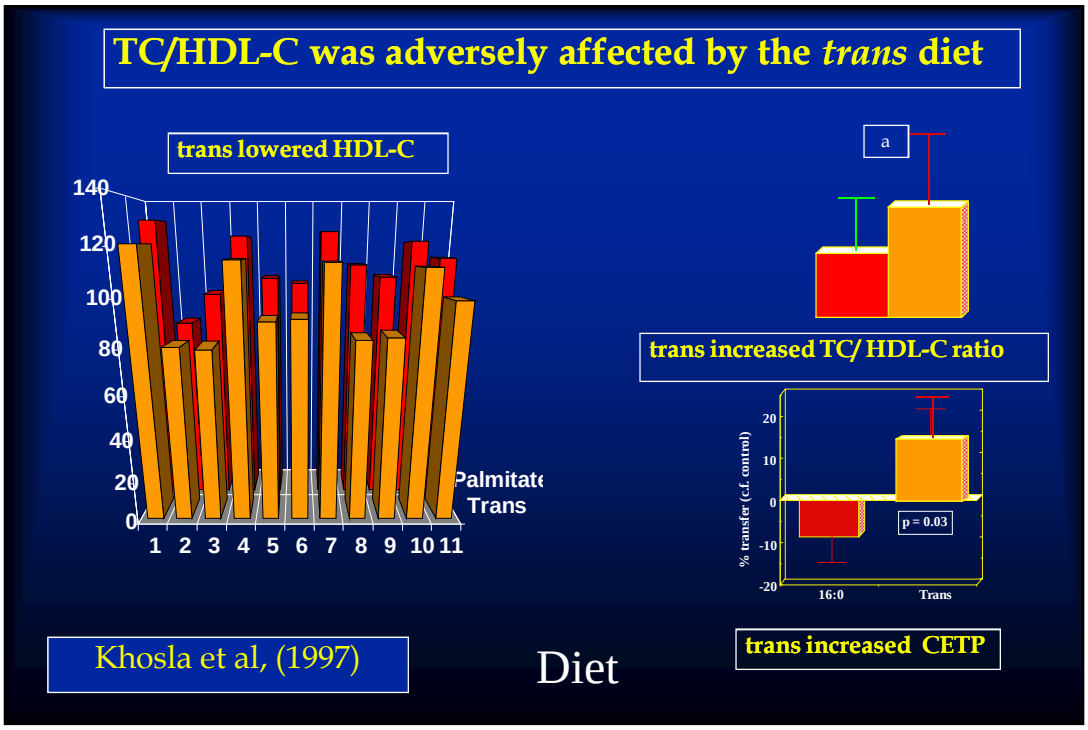

Effects of palmitic acid on LDL-C
ΔLDL-C (mg/dL)
30
25
20
15
10
5
0
-5
0
5
10
15
20
Δ16:0 (%en)
Khosla and Sundram (1996) Prog Lipid Res 35: 93-132

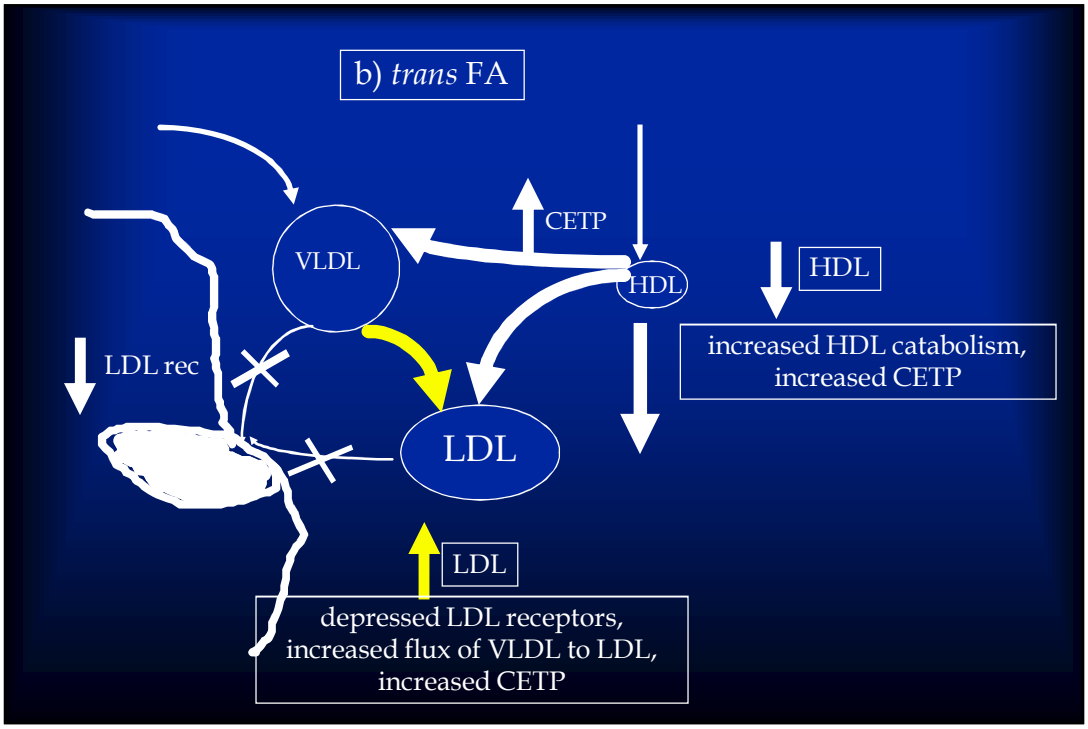

Effects of palmitic acid on LDL-C
ΔLDL-C (mg/dL)
Mata et. al.
Grundy et. al.
Zock et. al.
Nestel et. al.
Average American Intake
AAI
Sundram, Ng, Choudhury et. al.
30
25
20
15
10
5
0
-5
0
5
10
15
20
Δ16:0 (%en)
Khosla and Sundram (1996) Prog Lipid Res 35: 93-132

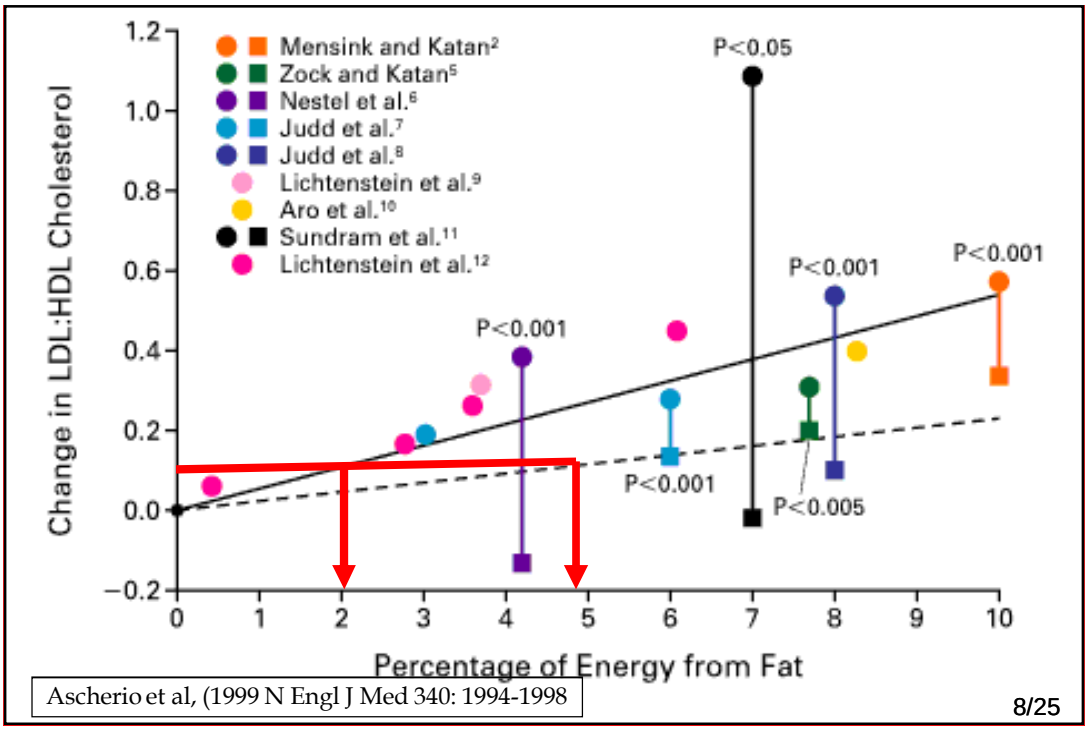

So what are the effects of fatty acids classes on lipoprotein cholesterol?
0.04
0.02
0
-0.02
LDL
S
cM
P
tM
0.04
0.02
0
HDL
S
cM
P
tM
MUFA & PUFA best.
Trans worse than SFA
0.04
0.02
0
-0.02
-0.04
TC/HDL
S
cM
P
tM
Changes shown in mmol/L for LDL and HDL. Adapted from Mensink et al Am J Clin Nutr (2003) 77: 1146-1155


Palm Olein and MUFA-rich Oils exert similar effects on the ratio of Total cholesterol to HDL cholesterol (TC/HDL-C) in human subjects
6
5
4
3
2
1
0
Ng (1992)M
Ng (1992)F
Choudhury (1995)
Sundram(1995)
Sundram(1997)
Tholstrup (2011)
Voon (2011)
Palm
Olive
Canola


What happens when trans replace saturates with the same amount of 18:1 & 18:2 ?
30
25
20
15
10
5
0
%energy
POLYS
OLEATE
SATS
TRANS
Palmitate
DIETS
Trans


TC/HDL-C was adversely affected by the trans diet
trans lowered HDL-C
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11
Palmitate
Trans
Khosla et al, (1997)
Diet
a
trans increased TC/ HDL-C ratio
20
10
0
-10
-20
% transfer (c.f. control)
p = 0.03
16:0
Trans
trans increased CETP





Ascherio et al, (1999 N Engl J Med 340: 1994-1998

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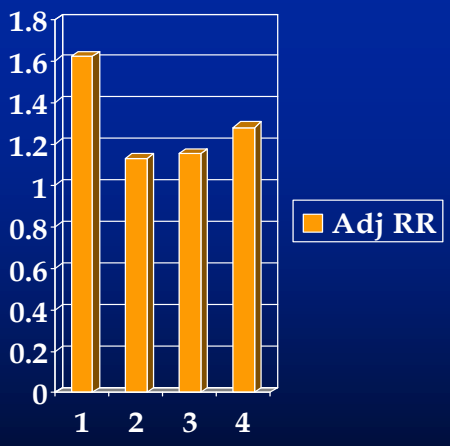
Effect of a 2% energy increase in trans fatty acid intake on CHD



- (1) Nurses Health Study n=80, 082. 14 yr follow-up 1.62 (1.23 - 2.13)
- (2) Health Professional Study n=43, 757. 6yr follow-up 1.13 (0.81-1.58)
- (3) Alpha-Tocopherol Beta Carotene Study n=21, 930. 6.1 yr follow-up 1.15 (0.96 - 1.35)
- (4) Zutphen Elderly Study n=667. 10 yr follow-up 1.28 (1.01-1.61)

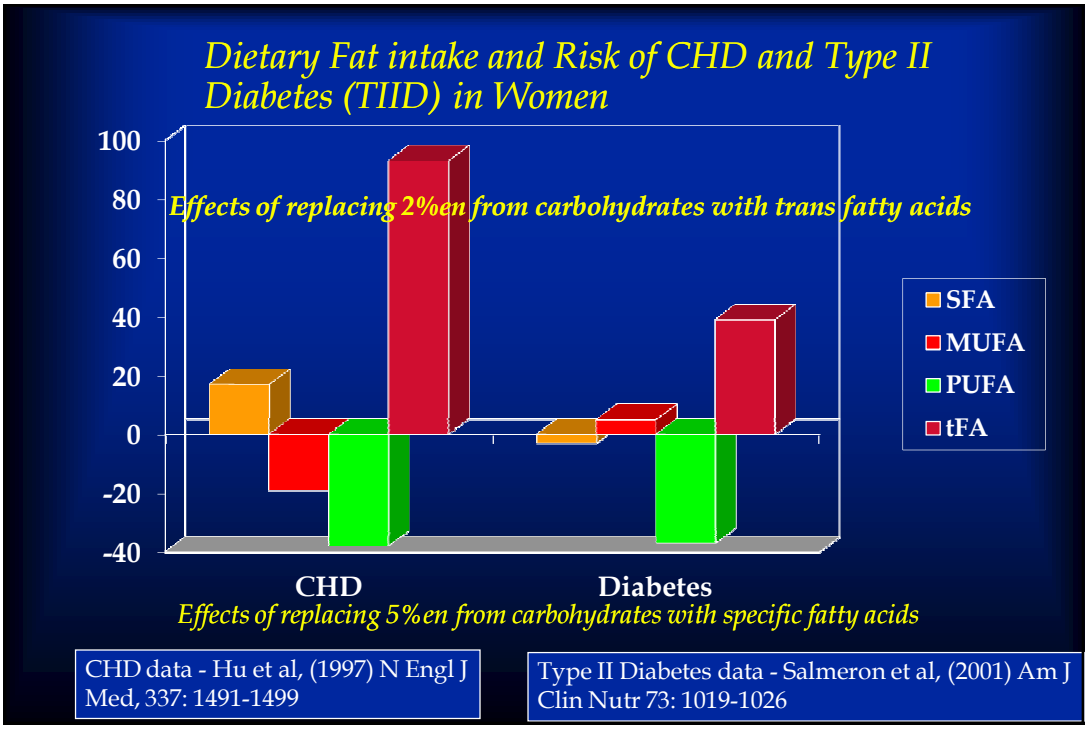
Oomen et. al., 2001

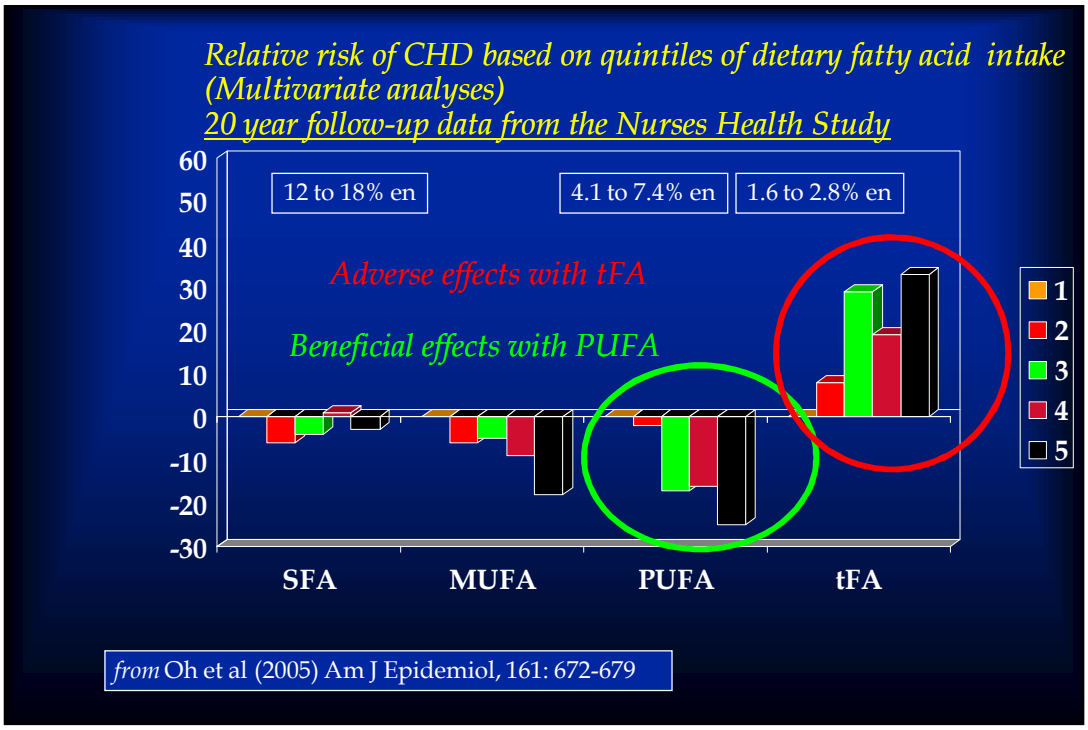
Dietary Fat intake and Risk of CHD and TIID in Women

- 5%en increase in SFA (vs carbohydrates)
  RR of CHD 1.17 (p=0.10): RR of TIID 0.97 (p=0.68)
- 5%en increase in MUFA (vs carbohydrates)
  RR of CHD 0.81 (p=0.05): RR of TIID 1.05 (p=0.52)
- 5%en increase in PUFA (vs carbohydrates)
  RR of CHD 0.62 (p=0.003) RR of TIID 0.63 (p<0.0001)
- 2%en increase in tFA (vs carbohydrates)
  RR of CHD 1.93 (p<0.001): RR of TIID 1. 39 (p=0.0006)

CHD data - Hu et al, (1997)

Type II Diabetes data - Salmeron et al, (2001)


Dietary Fat intake and Risk of CHD and Type II Diabetes (TIID) in Women
100
80
60
40
20
0
-20
-40
Effects of replacing 2%en from carbohydrates with trans fatty acids
SFA
MUFA
PUFA
tFA
CHD
Diabetes
Effects of replacing 5%en from carbohydrates with specific fatty acids
CHD data - Hu et al, (1997) N Engl J Med, 337: 1491-1499
Type II Diabetes data - Salmeron et al, (2001) Am J Clin Nutr 73: 1019-1026

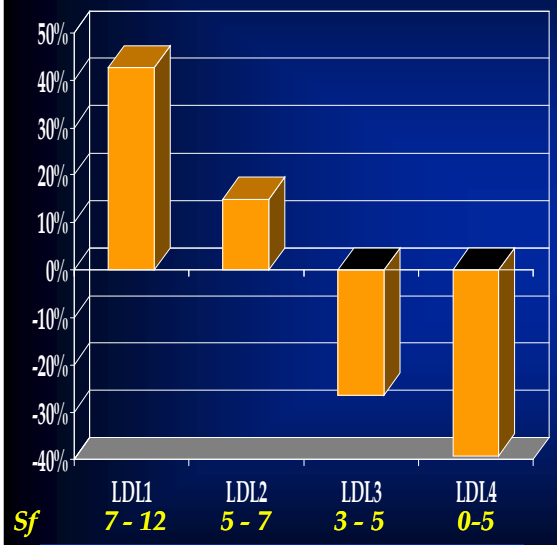

Relative risk of CHD based on quintiles of dietary fatty acid intake (Multivariate analyses)
20 year follow-up data from the Nurses Health Study
60
50
40
30
20
10
0
-10
-20
-30
12 to 18% en
4.1 to 7.4% en
1.6 to 2.8% en
Adverse effects with tFA
Beneficial effects with PUFA
1
2
3
4
5
SFA
MUFA
PUFA
tFA
from Oh et al (2005) Am J Epidemiol, 161: 672-679

So saturated fat and CHD …… a settled issue????

- Saturated fat → Increases LDL-C → Increases CHD risk
- Saturated fat → Increases CHD risk !

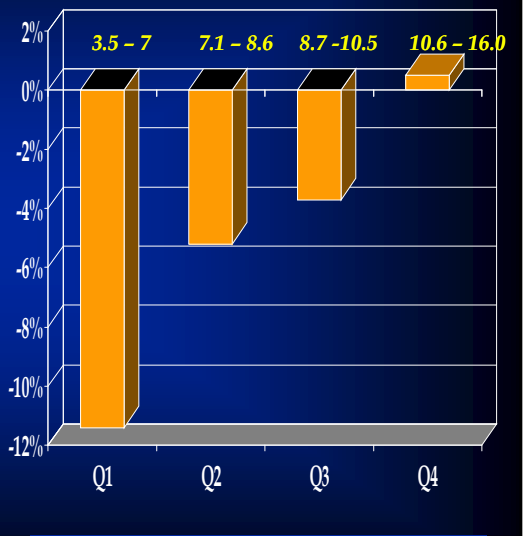
- Does it?? Some interesting bits of data……

Changes in LDL subfraction mass. Low → high fat diets (24% cal →45% cal: SFA 6% cal →18% cal)



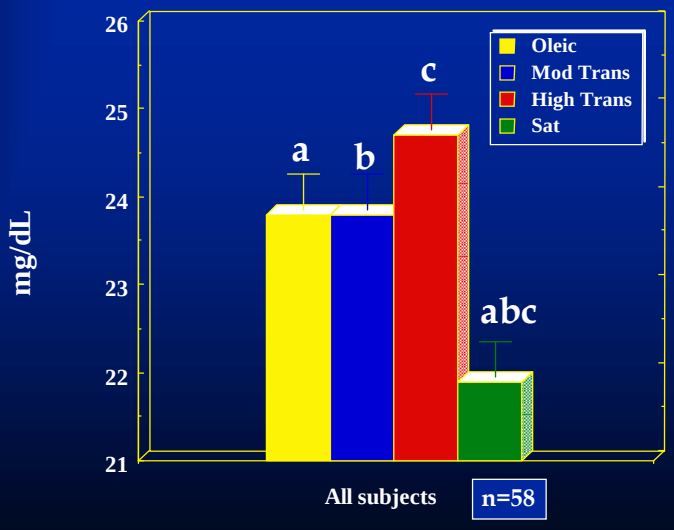
Dreon et al (1984) AJCN, 67: 828-836

Saturated fat intake and Changes in mean minimal Coronary Arterial Diameter in post-menopausal women



Mozaffarian et al, (2004) AJCN 80: 1175-1184-1499

SFA lower Lp(a) concentrations ?



Clevidence et al, (1997) Arterioscler. Thromb. Vasc. Biol. 17, 1657-1661,

If SFA decreased – what should be the replacement?

- **Pooled analysis of 11 studies. 4-10 year follow-up**
- **Pooled RR evaluated in 344, 696 subjects (5, 249 coronary events , 2155 coronary deaths)**
- **Risk of coronary events decreased when 5% energy from SFA replaced with PUFA not MUFA or carbohydrates**

Jakobsen et al , (2009) Am J Clin Nutr 89: 1425 - 1432

Additional meta-analysis showed no significant evidence for concluding SFA increase CHD risk

- **5-23 year follow-up**
- **Pooled RR evaluated in 347, 747 subjects (11, 006 developed CHD or stroke)**
- **Pooled RR for CHD – 1.07 (p=0.22)**
- **Pooled RR for Stroke – 0.81 (p=0.11)**
- **Pooled RR for CVD – 1.00 (p=0.89)**

Siri-Tarino et al , (2010) Am J Clin Nutr 91: 535 - 546

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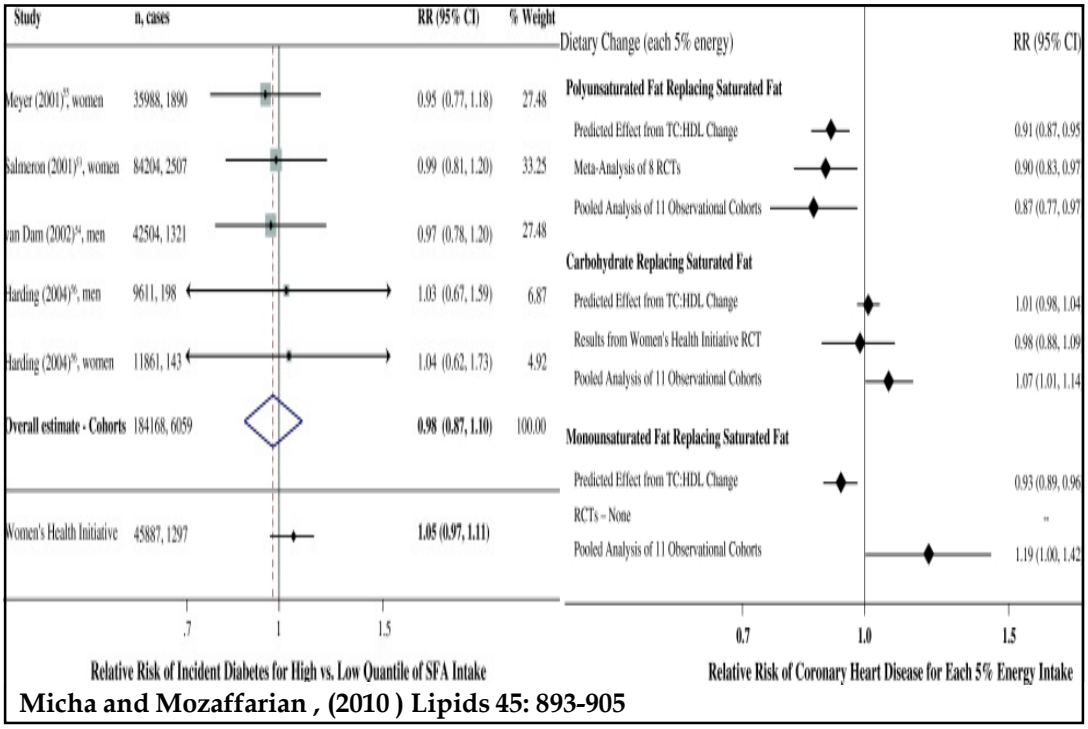

Micha and Mozaffarian , (2010) Lipids 45: 893-905

Summary

- **Palm Oil and its products – serve a multitude of nutritional needs**
- **Adequate supply makes palm oil *the* important player on the global stage**
- **Natural fatty acid profile of palm eliminates need for hydrogenation – so ideal for trans fat-free formulations.**
- **Even if trans FA replaced exclusively with SFA, CHD risk improved**
- **Vast array of products using palm oil blended with other oils already in the global market**