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UNIVERSITY  
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# ***Trans* fatty acids & health: are all '*trans*' bad?**

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# Why the Interest?

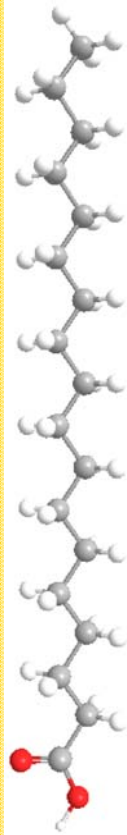
***Trans* fatty acids have been associated with the development of:**

- **Cardiovascular disease**
- **Systemic inflammation**
- **Type II diabetes**
- **Cancer**

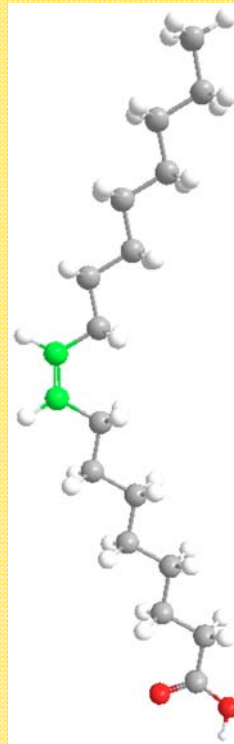
# What are *Trans* Fatty Acids?

- Typically a fatty acid is referred to as being a *trans* fatty acid (TFA) when it contains at least one double bond in the *trans* configuration
- TFA represent a group of positional and geometric isomers of both mono- and polyunsaturated fatty acids

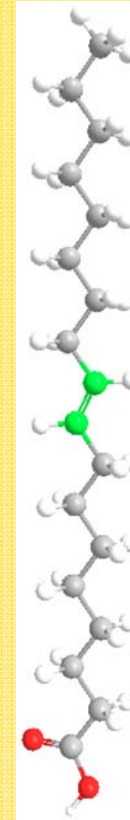
# Chemical Structure of TFA



**Stearic acid**  
**C18:0**



**Oleic acid**  
**C18:1 (*cis*-9)**



**Elaidic acid**  
**C18:1 (*trans*-9)**

➔ **Monounsaturated TFA** (e.g., *trans* isomers of 16:1, 18:1, 20:1, 22:1, 24:1)

➔ **Polyunsaturated TFA** (e.g., *trans* isomers of 18:2, 18:3, 20:2, 22:2)

# TFA Regulations

- **A number of countries have established policies aimed at reducing TFA intake in the human diet**
  - **Nutritional labelling of the content of TFA in food products**
  - **Legislation limiting the use of partially hydrogenated vegetable oils (PHVO) in industrially prepared foods**

# Dietary Sources

➤ **A *trans* double bond is most commonly introduced into a fatty acid chain by:**

**– Chemical partial-hydrogenation processes (PHVO; industrial sources)**

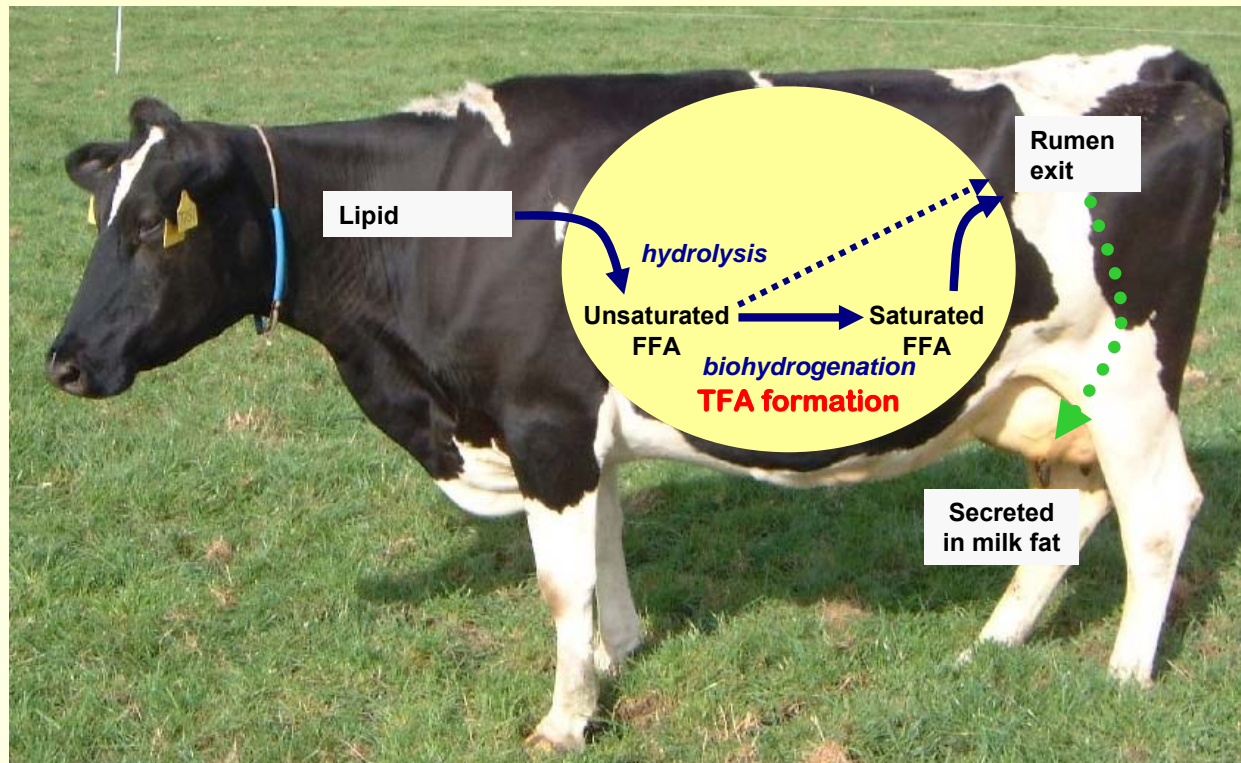
**– Formation of intermediates during rumen biohydrogenation  
(milk fat; ruminant sources)**

# **Key Take Home Message:**

- 1. Presence of TFA in milk fat is due to rumen biohydrogenation of unsaturated fatty acids**

# Rumen Biohydrogenation is Key

- Rumen is large anaerobic fermentation vat
- Dietary unsaturated FA toxic to rumen microbes

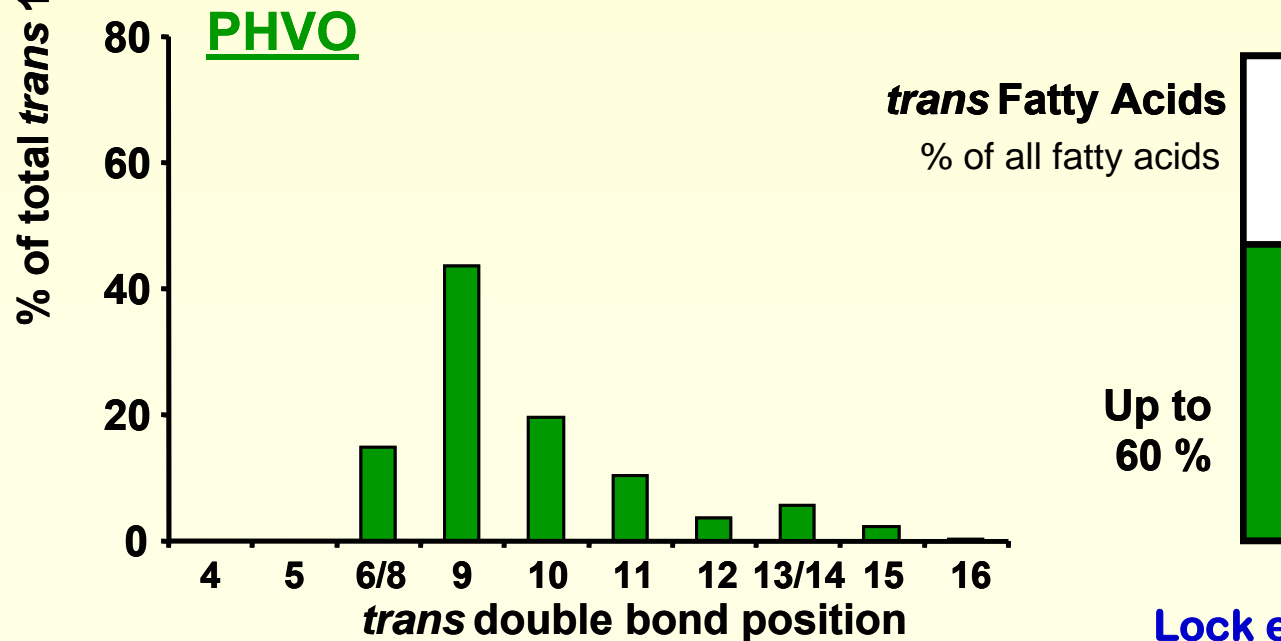
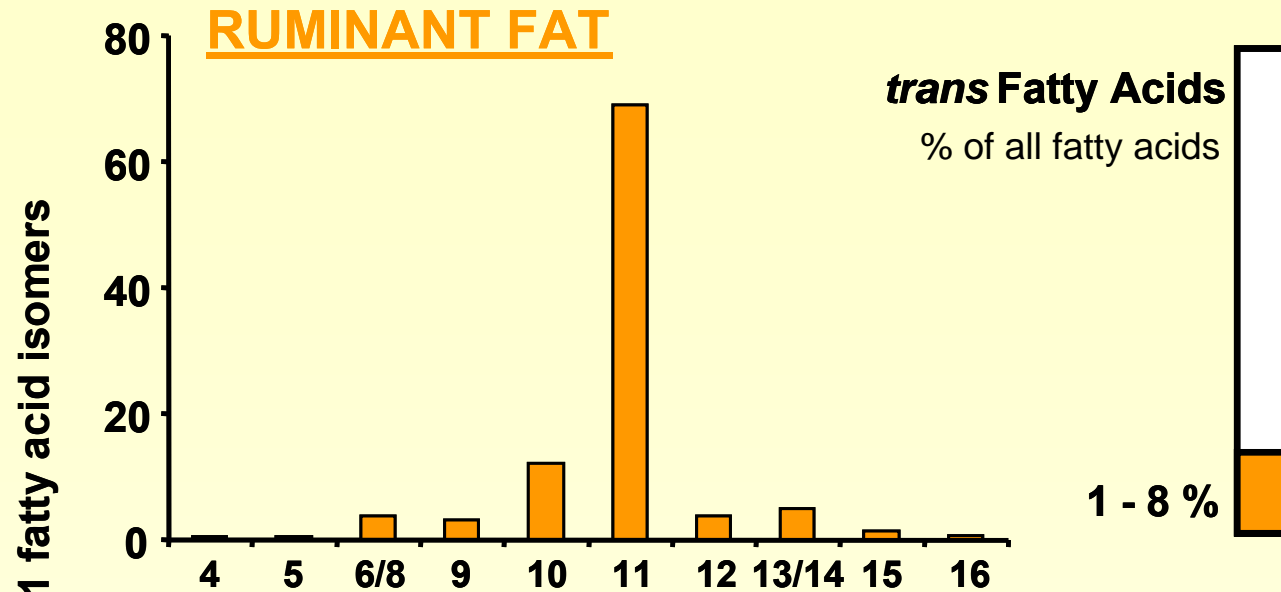


➤ **A natural process**

# **Key Take Home Message:**

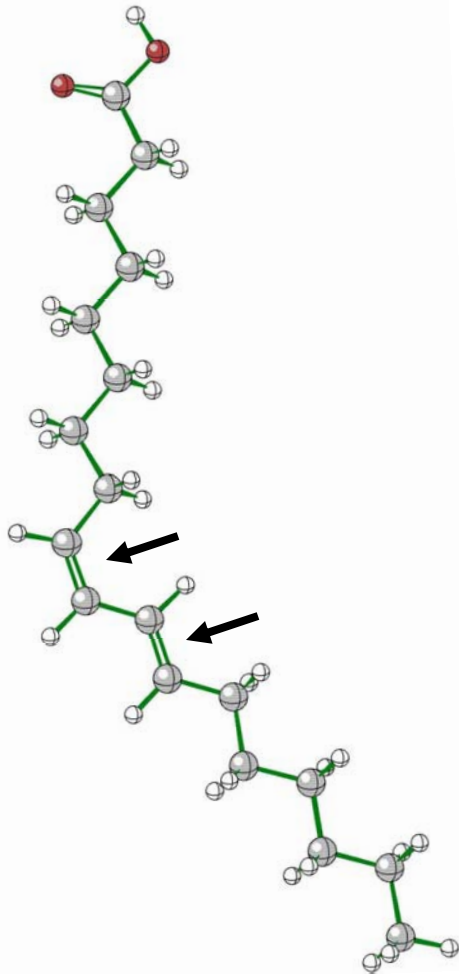
- 2. Significant differences in the total amount and isomer profile of TFA from industrial and ruminant-derived sources**

# Ruminant vs. Industrial Sources



Lock et al. (2005)

# Conjugated Linoleic Acids & Milk Fat



*cis*-9, *trans*-11 CLA  
Rumenic Acid

## Biological Effects

Anticarcinogenic effects (in vivo and in vitro)

Antiatherogenic properties

**“...conjugated linoleic acid (CLA) is the only fatty acid shown unequivocally to inhibit carcinogenesis in experimental animals.”**

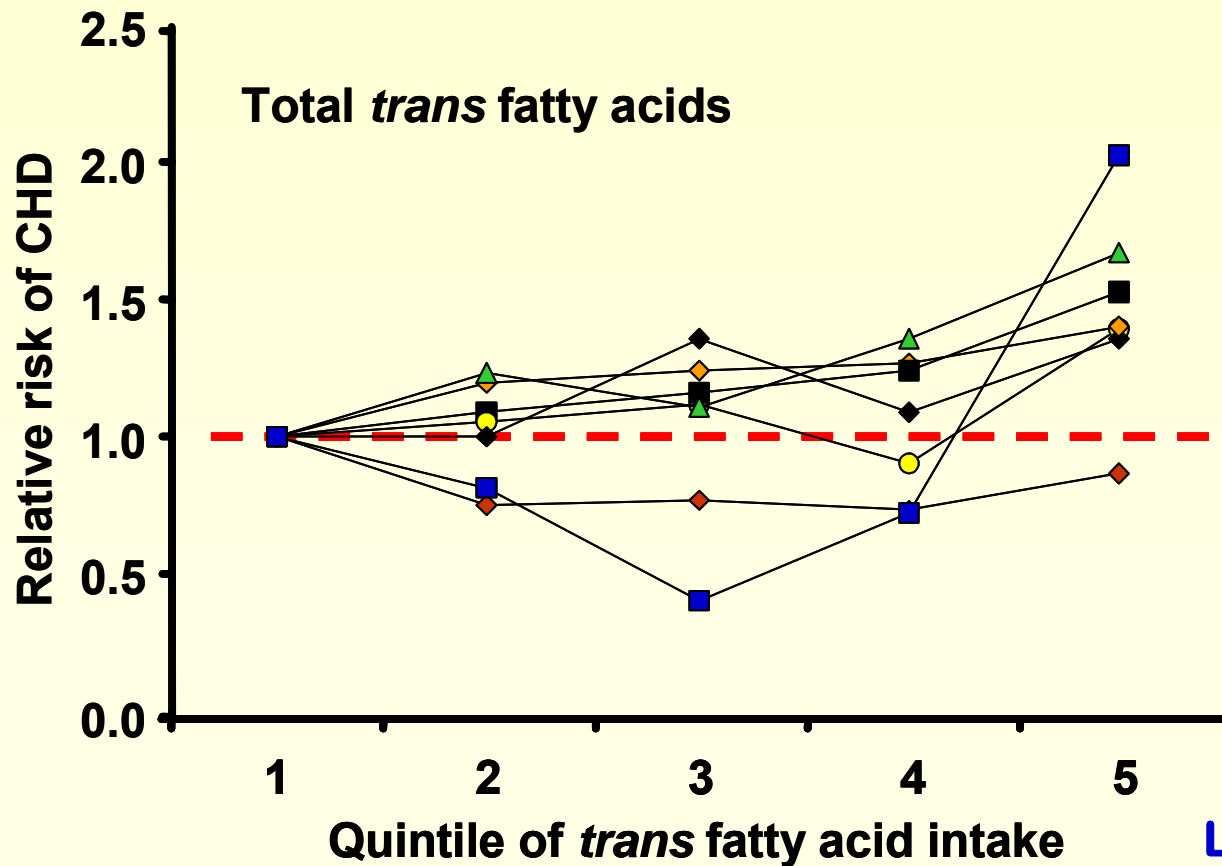
**Carcinogens and Anticarcinogens in the Human Diet  
National Academy of Science, 1996**

# **Key Take Home Message:**

- 3. There is a growing body of scientific evidence indicating differences in human health effects between industrial and ruminant sources of TFA**

# Summary of Epidemiological Studies

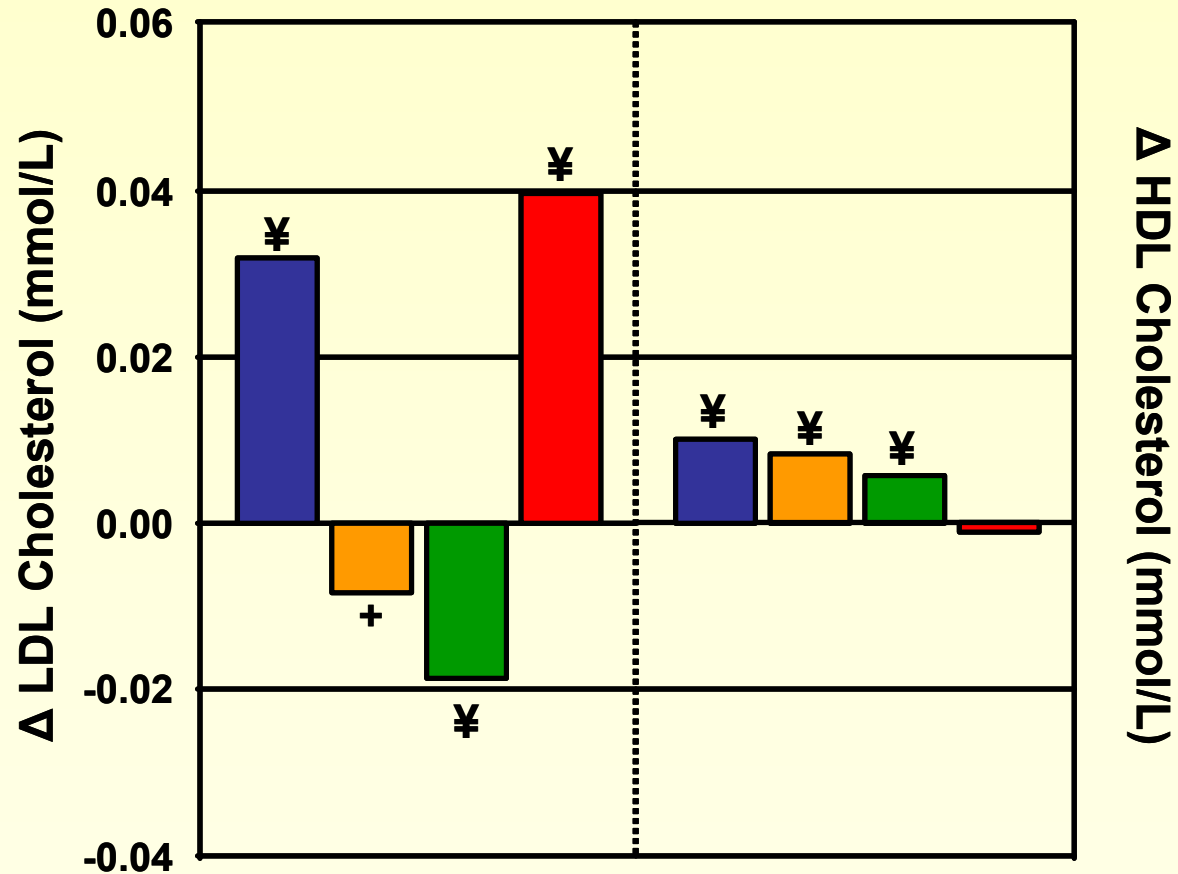
- Prospective-cohort and case-control studies have observed an association between total TFA intake and increased risk of CHD



Lock et al. (2005)

# Meta-Analysis of 60 Trials

$\Delta$  Cholesterol when 1% of carbohydrate energy is replaced with fatty acids



■ Saturated fatty acids

■ *cis* Monounsaturated fatty acids

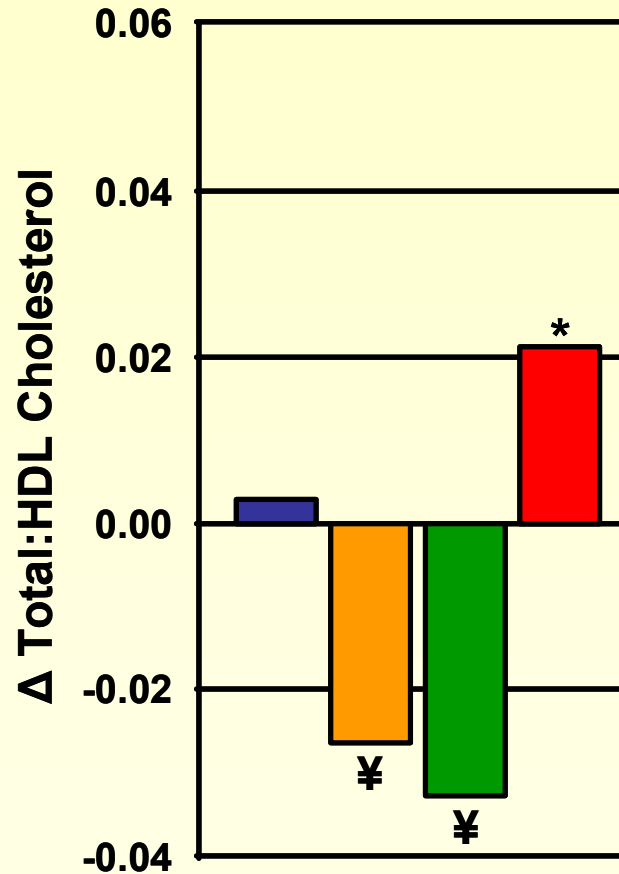
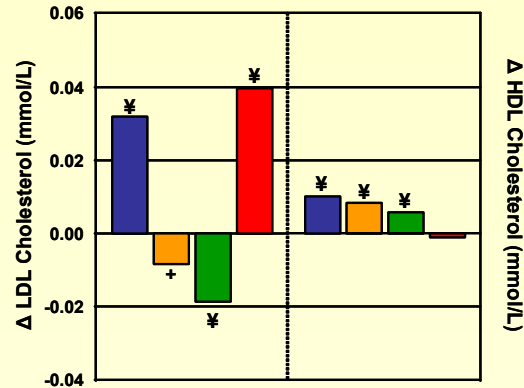
■ *cis* Polyunsaturated fatty acids

■ *trans* Monounsaturated fatty acids

Mensink et al., 2003

# Meta-Analysis of 60 Trials

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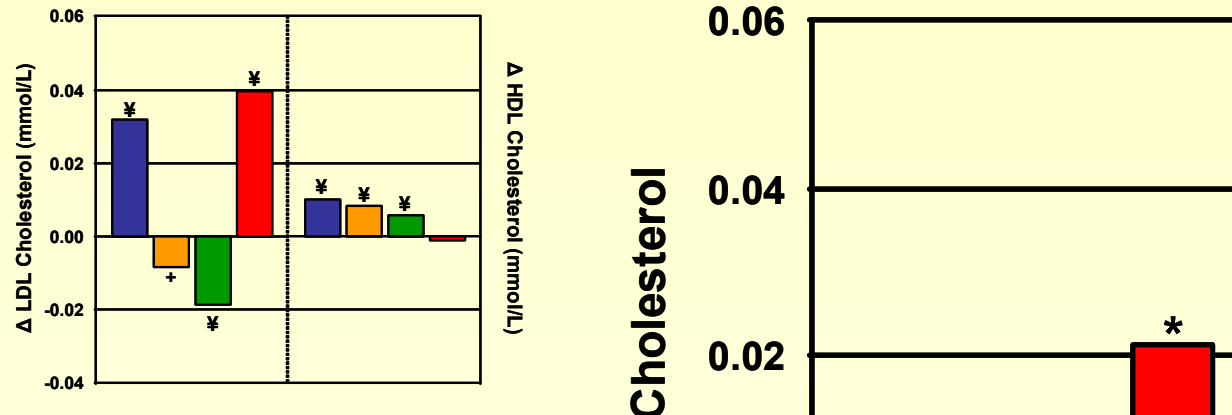
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■ *cis* Polyunsaturated fatty acids

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# Meta-Analysis of 60 Trials

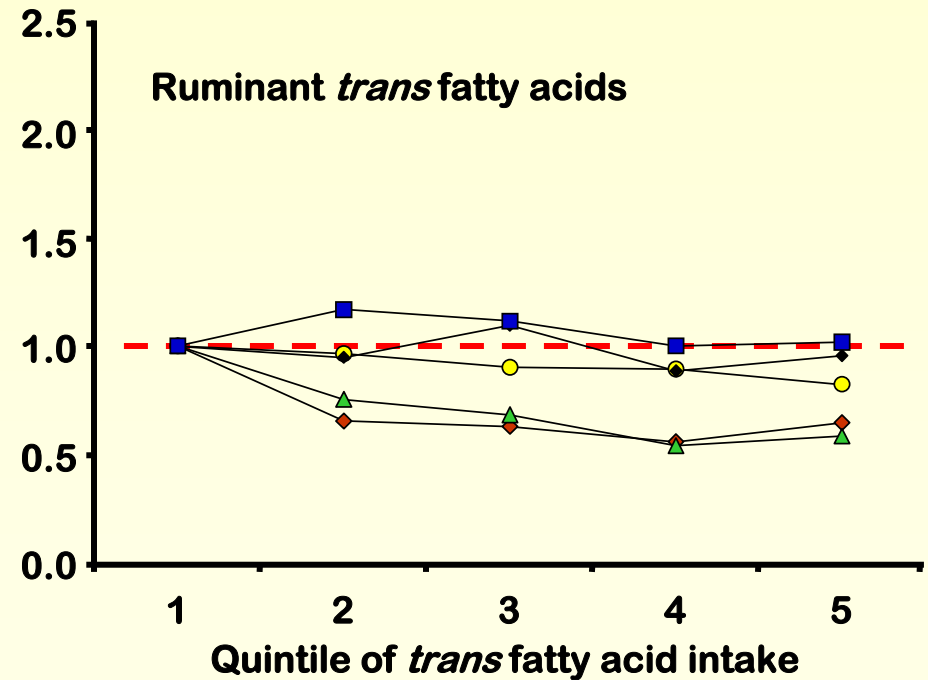
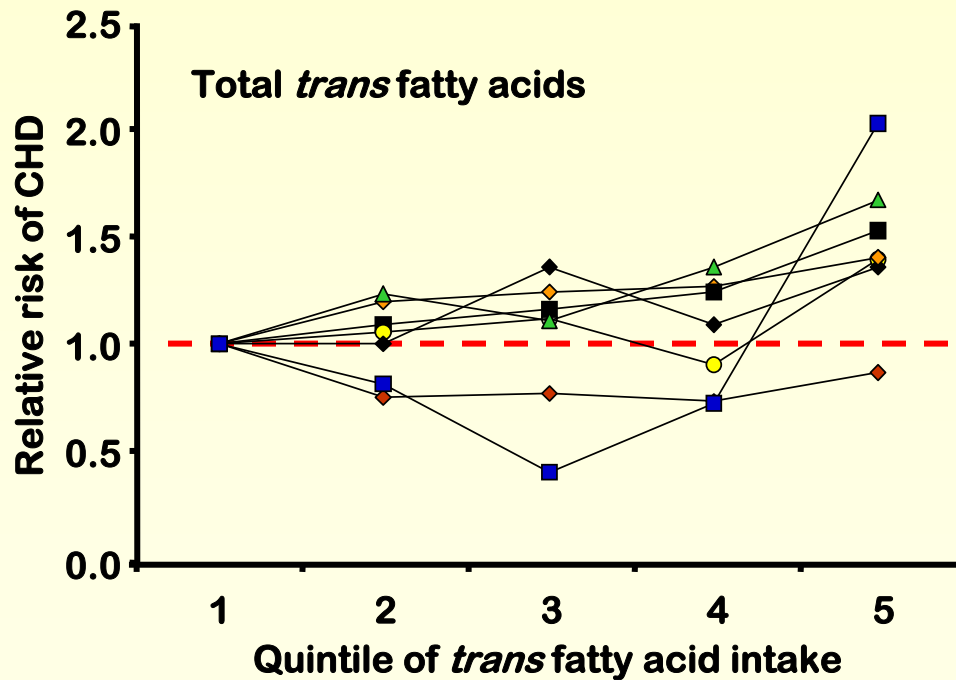
**Δ Cholesterol when 1% of carbohydrate energy is replaced with fatty acids**



- All the dietary intervention studies contributing to this meta-analysis used **industrial** sources of TFA
- Data such as this and by others have been broadly extrapolated to imply that high consumption of any and all TFA is associated with an increased risk of **CHD**

# Summary of Epidemiological Studies

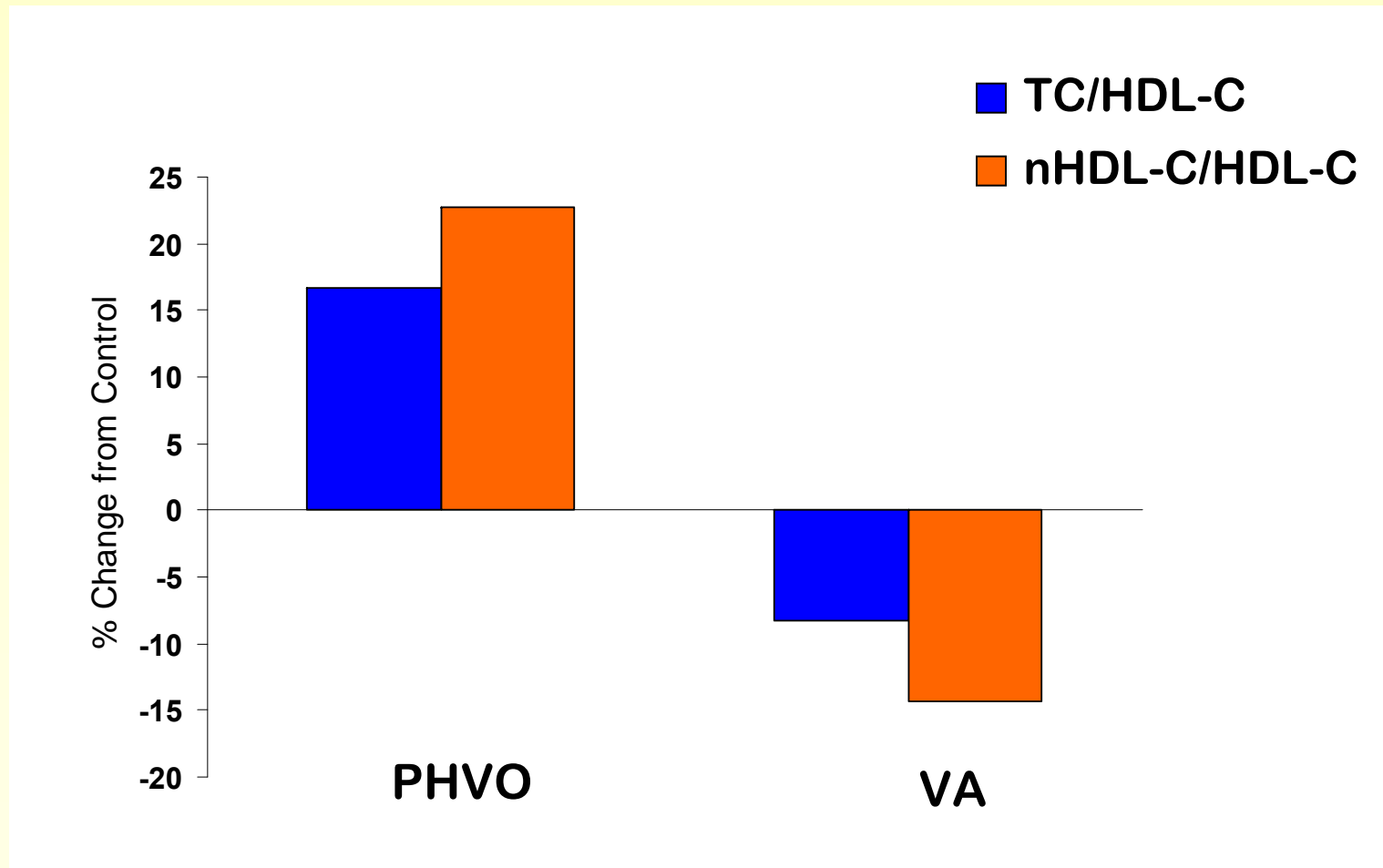
- Ascherio et al., 1994
- ◆ Ascherio et al., 1996
- ◆ Bolton-Smith et al., 1996: ♂
- ◆ Bolton-Smith et al., 1996: ♀
- Hu et al., 1997
- Pietinen et al., 1997
- ▲ Willett et al., 1993



# Effects of Dairy Foods Enhanced in TFA on Lipoprotein Metabolism in Humans

- **Desroches et al. (2005) – overweight & obese men, 4 wk**
  - supplied 2.2 g/d RA and 4.7 g/d *trans*-18:1
- **Tricon et al. (2006) – healthy middle aged men, 6 wk**
  - supplied 1.4 g/d RA and 6.3 g/d *trans*-18:1
- **Tholstrup et al. (2006) – healthy young men, 5 wk**
  - supplied 1.5 g/d RA and 3.6 g/d VA
- **Chardigny et al. (2008) – healthy young men & women, 3 wk**
  - supplied ~3 g/d RA and 11-12 g/d *trans*-18:1
- **Despite significant increases in TFA intake, no pattern of negative effects on plasma cholesterol markers was observed**

# Effect of hydrogenated fat and pure vaccenic acid on lipoprotein risk factors in hamsters



Tyburzcy et al. (J. Nutr., in press)

**Little or no epidemiological,  
clinical or animal data available  
indicating that ruminant (milk fat)  
sources of TFA negatively impact  
human health**

**Individuals do not consume fatty acids as a dietary entity, but rather as fats in food**

➤ **This is an important consideration in evaluating health implications**

# Summary

- **Dairy products are a major source of dietary TFA**
  - **BUT...there is little or no evidence that ruminant sources of TFA effect the risk of CHD**
  - **In contrast, the adverse effects of dietary industrial TFA on risk of CHD are well established**
  - **Industrial and ruminant sources of TFA differ in isomer profile**
    - **Ruminant sources consist mainly of vaccenic acid (*trans*-11 C18:1) and rumenic acid (*cis*-9 *trans*-11 CLA) which may have significant benefits to human health**



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# Questions?

