

## Bioactive Fatty Acids in Milk Fat: Are All *trans* Fatty Acids the Same?

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Field of Nutrition Seminar  
March 3, 2008

## Nutritional Quality & Consumer Perceptions

- Consumers recognize the importance of animal products as sources of nutrients
- There is also a growing consumer recognition of the link between diet and health
- Scientists are increasingly asked to clarify the role of specific foods and food components in health maintenance and disease prevention

## Biological Activity of Fatty Acids

- Dietary fatty acids have diverse biological functions:
  - Sources of energy
  - Structural components of cell membranes
  - Precursors for lipid signaling molecules
- Bioactive fatty acids
  - Regulation of metabolic processes
  - Alteration of gene expression (nutrigenomics)
  - e.g. omega-3 fatty acids & CLA

## Why the Interest in TFA?

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

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

**Crisco 0 Grams Trans Fat Per Serving**  
All-Vegetable Shortening, 100% Delicious Recipes

**0 Grams Trans Fat**  
All-Vegetable Shortening

**GREAT NEWS!**  
AMERICA'S FAVORITE SHACKS HAVE 0 GRAMS TRANS FATS.

**100% GREAT TASTE. 0 GRAMS TRANS FATS.**

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Nutrition Facts	
Serving Size 1 cup (228g) Serving Per Container 2	
Amount Per Serving	
<b>Calories</b> 250	Calories from Fat 110
% Daily Value*	
<b>Total Fat</b> 12g	<b>18%</b>
<b>Saturated Fat</b> 3g	<b>15%</b>
<b>Trans Fat</b> 1.5g	
<b>Cholesterol</b> 30mg	<b>10%</b>
<b>Sodium</b> 470mg	<b>20%</b>
<b>Total Carbohydrate</b> 31g	<b>10%</b>

NYC THE NEW YORK CITY DEPARTMENT of HEALTH and MENTAL HYGIENE  
Health



**Clear Your Kitchen of Trans Fat**

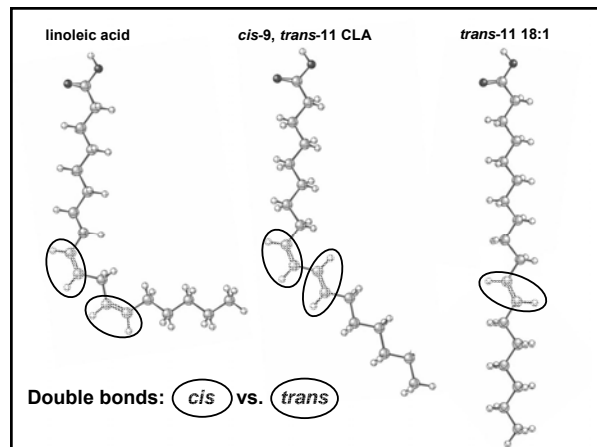
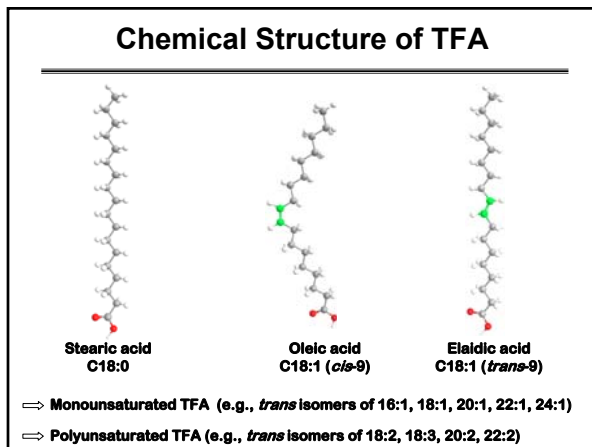
CALL 311  
and ask for more info  
or visit [nyc.gov/health](http://nyc.gov/health)  
for more information

- 1. CHANGE**  
Your recipe.  
For cooking and baking, choose non-hydrogenated vegetable oils.  
For baking, use non-hydrogenated shortening or butter.  
Do not use margarine.
- 2. CHOOSE**  
Healthy options.  
Look for products with 100% monounsaturated or polyunsaturated oils.  
Do not use margarine.
- 3. ORDER**  
Ingredients. Look for products with 100% monounsaturated or polyunsaturated oils.  
Do not use margarine.

**HEALTH DEPARTMENT ASKS RESTAURATEURS AND FOOD SUPPLIERS TO VOLUNTARILY MAKE AN OIL CHANGE AND ELIMINATE ARTIFICIAL TRANS FAT**

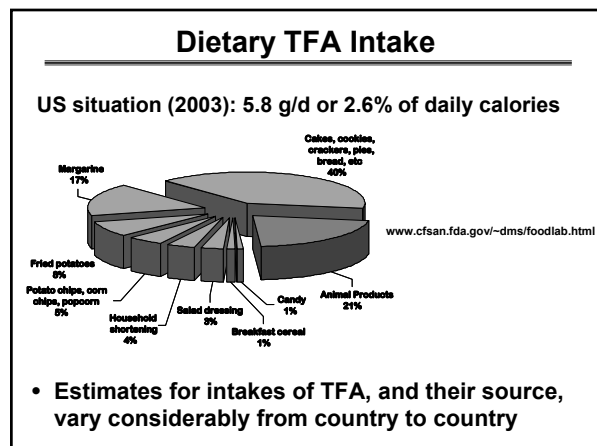
## What are *Trans* Fatty Acids?

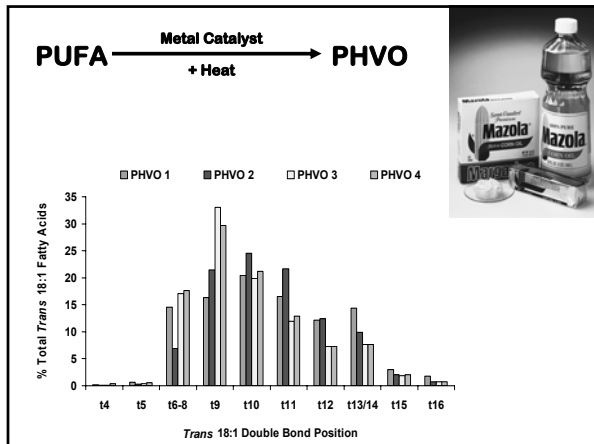
- Typically a fatty acid is referred to as being a *trans* fatty acid (TFA) when it contains at least one double bond in the *trans* configuration
- TFA represent a group of positional and geometric isomers of both mono- and polyunsaturated fatty acids



## What are the 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 (ruminant-derived; natural sources)

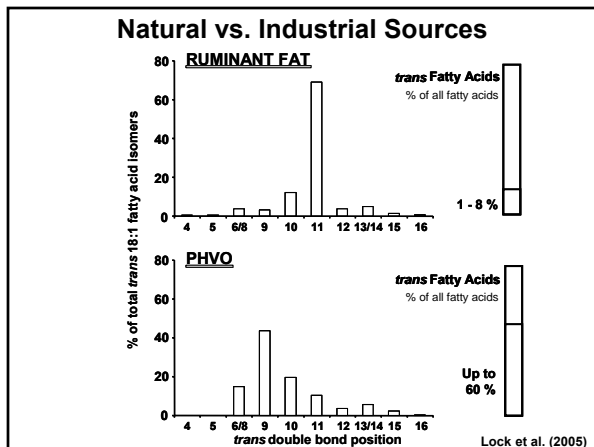
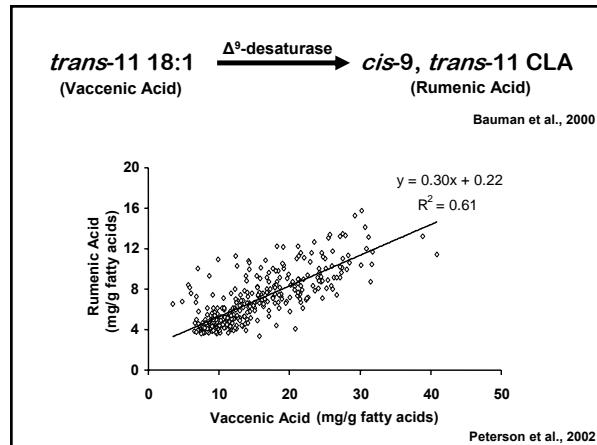
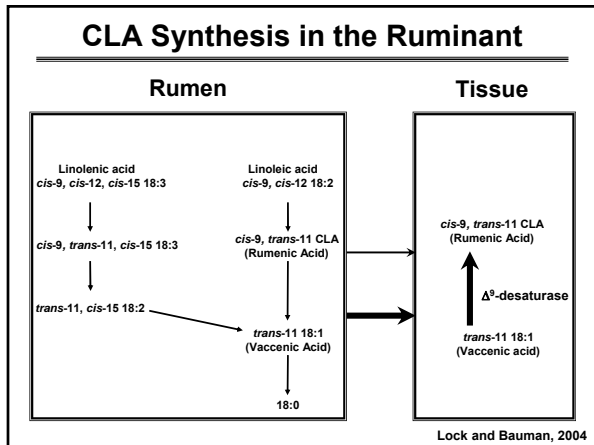




### Rumen Biohydrogenation Is Key

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

**➤ A natural process!**



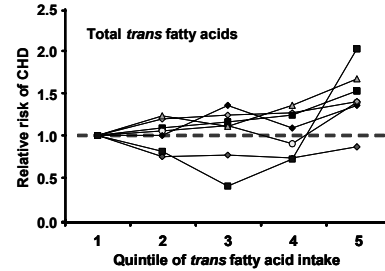
### Key Take Home Message:

Major differences in the total amount and isomer profile of TFA from industrial and naturally-derived sources

## What about TFA and Human Health?

## Summary of Epidemiological Studies

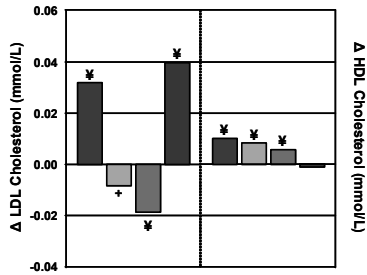
- Prospective-cohort and case-control studies have observed an association between total TFA intake and increased risk of CHD



Lock et al. (2005)

## Meta-Analysis of 60 Trials

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

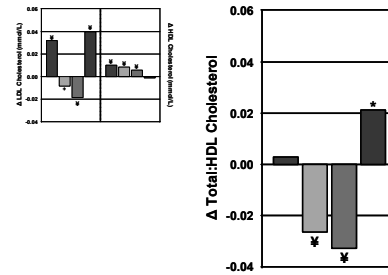


Saturated fatty acids       *cis* Monounsaturated fatty acids  
 *cis* Polyunsaturated fatty acids       *trans* Monounsaturated fatty acids

Mensink et al., 2003

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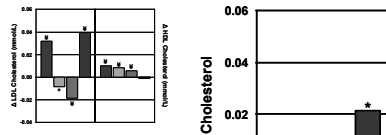


Saturated fatty acids       *cis* Monounsaturated fatty acids  
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Mensink et al., 2003

## 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

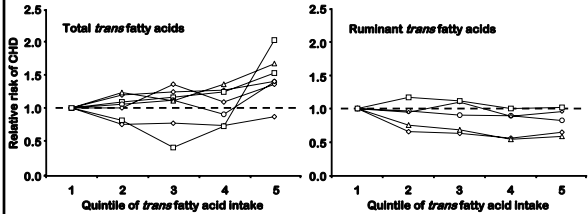
Mensink et al., 2003

## Food Industry Response

- Food manufacturers have developed and implemented various technologies to reduce TFA levels in their products
  - Modification of the hydrogenation process
  - Use of interesterification
  - Use of fractions high in solids from natural oils
  - Use of trait-enhanced oils

## 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



Lock et al. (2005)

## TFA & Human Health

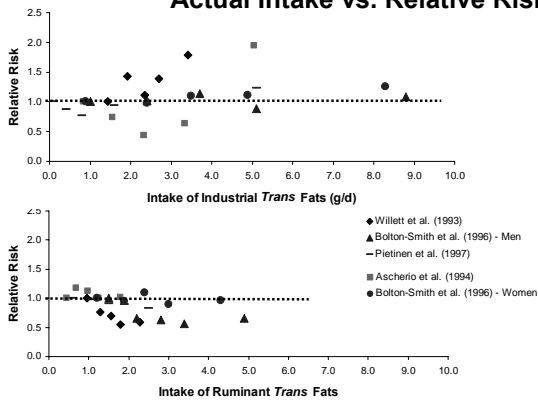
- Is there a plausible biological explanation for these different epidemiological observations?

The quintiles of intake represent very different quantities of TFA

- Ruminant-derived: 0.5 to 2.5 g/d
- Industrially-derived: 0.1 to 5.1 g/d

Weggemans et al., 2004

## Actual Intake vs. Relative Risk

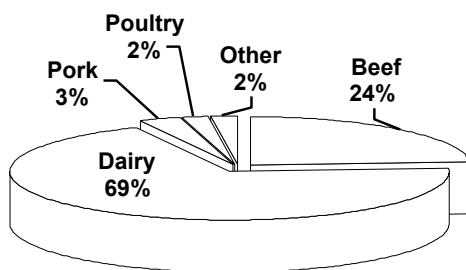


## TFA & Human Health

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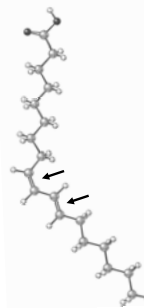
Differences in the profile of TFA isomers from industrial and ruminant derived sources

## Distribution of CLA Sources in the U.S. Diet



Ritzenthaler et al., 2001

## Conjugated Linoleic Acids (CLA)

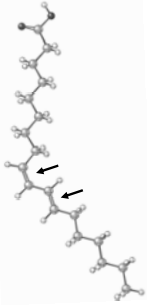


*cis-9, trans-11* CLA  
Ruminic Acid

“...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

## Conjugated Linoleic Acids (CLA)



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

### Biological Effects

Anticarcinogenic effects (in vivo and in vitro)

Antiatherogenic properties

Altered nutrient partitioning and lipid metabolism

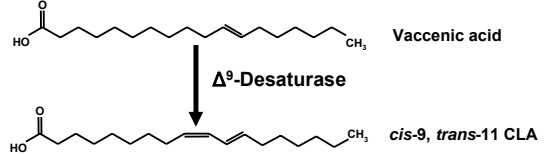
Antidiabetic (type II) and reduced hyperglycemia

Immune modulation

Improved bone mineralization

## TFA & Human Health

### Endogenous Synthesis



- VA is the only major dietary TFA that can be acted upon in this manner
- Humans convert ~20% of dietary vaccenic acid to RA
- At least 50% of RA in humans come from dietary-derived vaccenic acid

## 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
- Motard-Belanger et al. (2008) – healthy men (18 – 65y) 4 wk  
- supplied ~0.4-2 g/d RA and 2-10 g/d *trans*-18:1
- Despite significant increases in TFA intake, no pattern of negative effects on plasma cholesterol markers was observed



## Project TRANSFACT

(TRANS Fatty Acid CollaboraTion)

Objective: Comparative Effect of TFA Isomers on CVD Risk in Healthy Humans

- Results published in March (2008) issue of AJCN

## TRANSFACT STUDY

- Human clinical study feeding high levels of TFA (11-12 g/d) at ~5% of daily energy, 3 wk
- Healthy young men and women (n = 40)
- TFA from 2 sources
  - Industrial (t9 & t10 18:1 ~ 14.2% of total fat)
  - Natural (t11 18:1 ~ 13.9% of total fat)
- Cornell – produced natural TFA butter oil
- Nestlé – made foods (butter, cheese, biscuits)
- INRA – conducted clinical study & plasma analyses

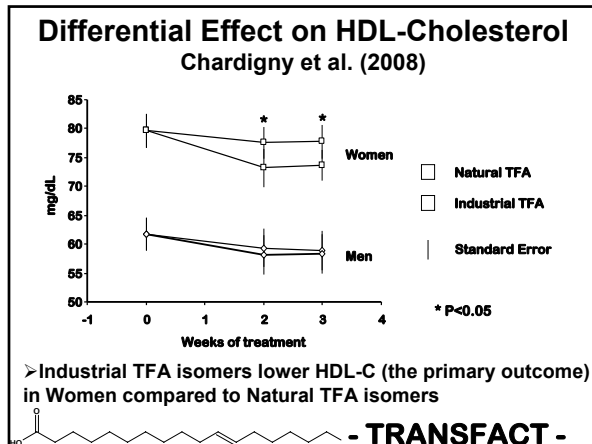
## TRANSFACT STUDY

- Monitored wide range of biomarkers for CVD risk
 

Total-cholesterol	apoA1
HDL-cholesterol	apoB
LDL-cholesterol	Lp(a)
HDL-cholesterol	CETP
Triglycerides	Fatty acid profiles of plasma lipid fractions
HDL & LDL particle size/distribution	

No negative effects were observed for TFA from milk fat.

- Results published in AJCN (March, 2008)



**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

### Milk Consumption and CVD

10 cohort studies

- 4 UK, 4 USA, 1 Netherlands, 1 Japan
- Comprise almost 400,000 subjects
- Over 8500 heart attacks or strokes

"Cohort studies provide no convincing evidence that milk is harmful. .... the studies, taken together, suggest that milk drinking may be associated with a small but worthwhile reduction in heart disease and stroke risk."

Elwood et al., 2004

### Effect of Dairy Consumption on Blood Lipids in Adults (NHANES, 1999-2002)

Variable, mg/dl	Dairy Servings Consumed Per Day					
	<1	1-1.5	1.5-2.5	2.5-3.5	3.5-4.5	>4.5
Total Cholesterol	203.7	205.1	201.5	202.3	204.0	205.5
LDL-Cholesterol	122.6	121.5	118.4	119.3	116.2	120.7
HDL-Cholesterol	50.4	50.6	51.2	52.2	52.1	51.1
Triglycerides	153.5	137.1	169.8	137.7	143.0	157.3

V. Fulgoni, unpublished

➤ There was no effect of dairy consumption on total cholesterol, LDL-cholesterol, HDL-cholesterol, or triglycerides

### Take Home Message:

- Growing body of scientific evidence indicating differences in human health effects between industrial and natural sources of TFA
- Little or no epidemiological, clinical or animal data indicating that natural (milk fat) sources of TFA negatively impact human health!

### What is the Status of 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 PHVO in industrially prepared foods

## Challenges

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### Not all fatty acids are equal!

- Location and geometric configuration of double bonds results in marked differences in biological effects; it is essential that we better understand these differences

## Challenges

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### Education of the public is essential

- Dealing with inappropriate and inaccurate generalizations about fat will be of special importance.

## Acknowledgements

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