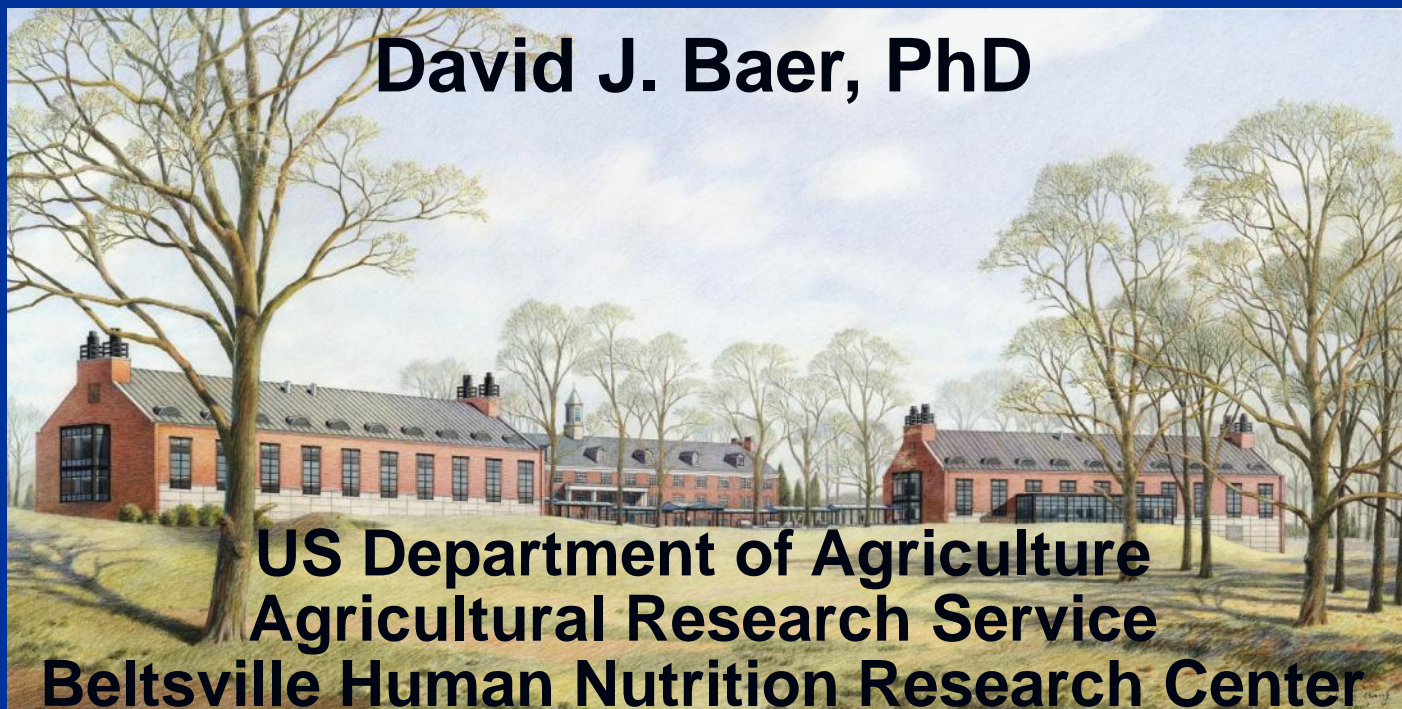




# New Findings on Dairy Trans Fat and Heart Disease Risk

IDF World Dairy Summit 2010, 08 - 11 November 2010, Auckland, New Zealand



**David J. Baer, PhD**

**US Department of Agriculture  
Agricultural Research Service  
Beltsville Human Nutrition Research Center**

# Questions?

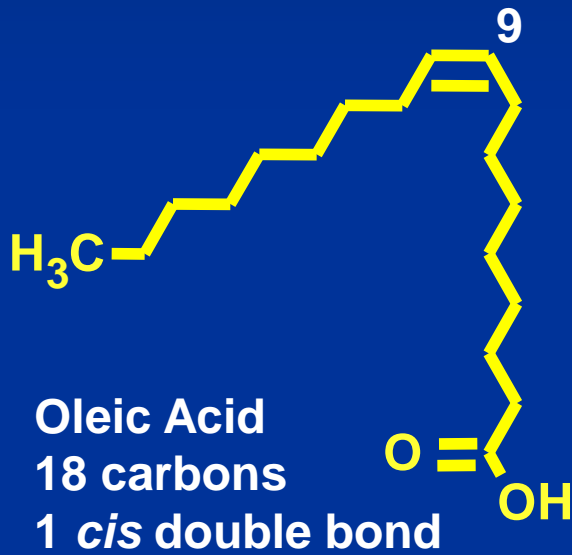
1. Do trans fatty acids from natural and industrial sources have the same impact on coronary heart disease risk?
2. Is there a need to regulate them differently?



# Overview

- **What are dairy trans fatty acids?**
  - Vaccenic acid
  - Rumenic acid
- **What is the current state of knowledge?**
  - Epidemiologic
  - Human clinical interventions
- **New findings**

# Monoenes



Elaidic Acid

18 carbons

1 *trans* double bond

H<sub>3</sub>C

Vaccenic Acid

18 carbons

1 *trans* double bond

H<sub>3</sub>C

Stearic Acid

18 carbons

0 double bond

H<sub>3</sub>C

9

11

OH

OH

OH

OH

OH

# Trans Monoenes in Milk Fat

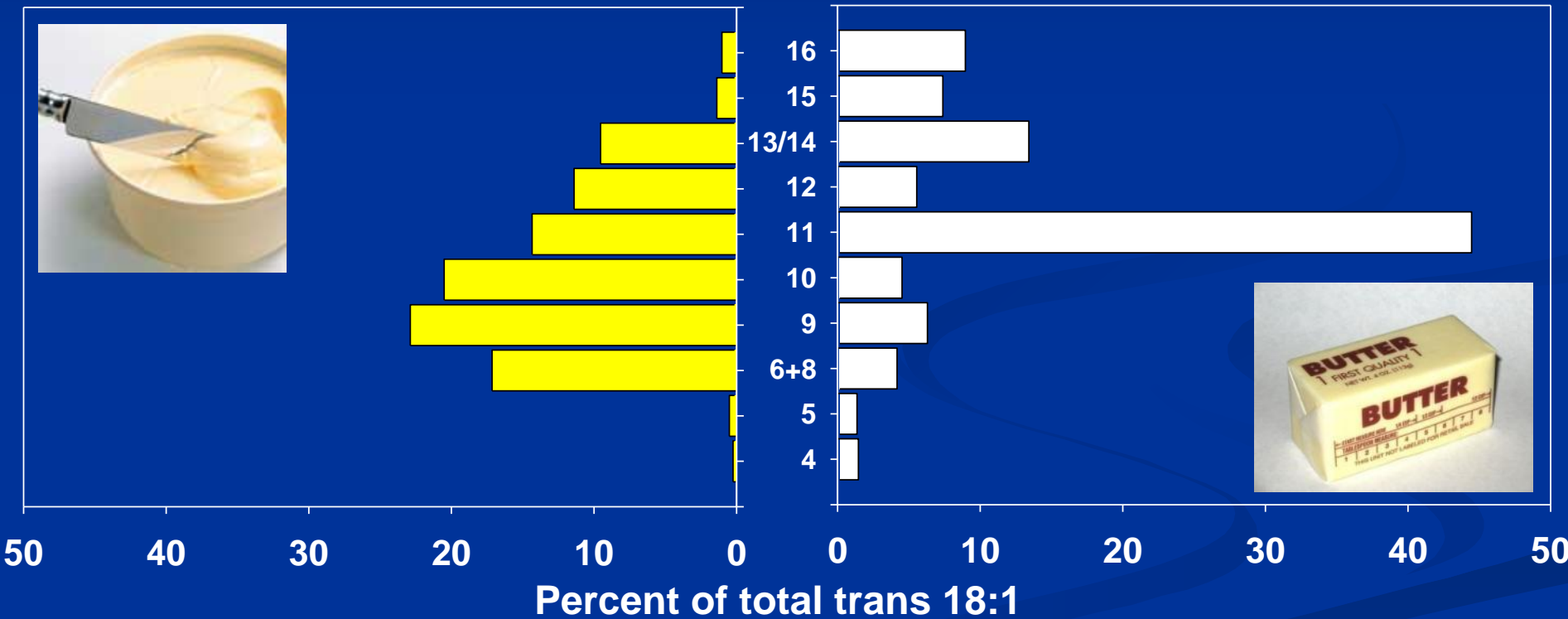
Chain length	wt% of fatty acid
Trans 14:1	0.03
Trans 15:1	0.03
Trans 16:1	0.13
Trans 17:1	0.01
<i>Trans 18:1</i>	<i>3.7</i>
Trans 19:1	0.01
Trans 20:1	0.01
Trans 23:1	0.01
Trans 21:1, 22:1 & 24:1	trace

# Distribution of trans 18:1 Isomers in Industrial and Natural Sources

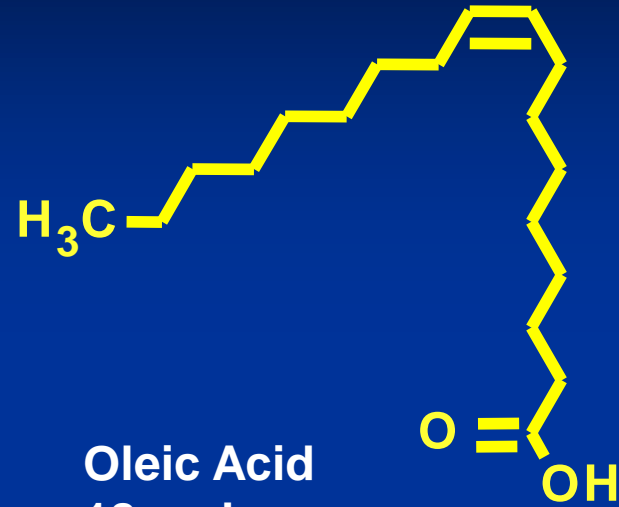
## Margarine



## Bovine milk fat



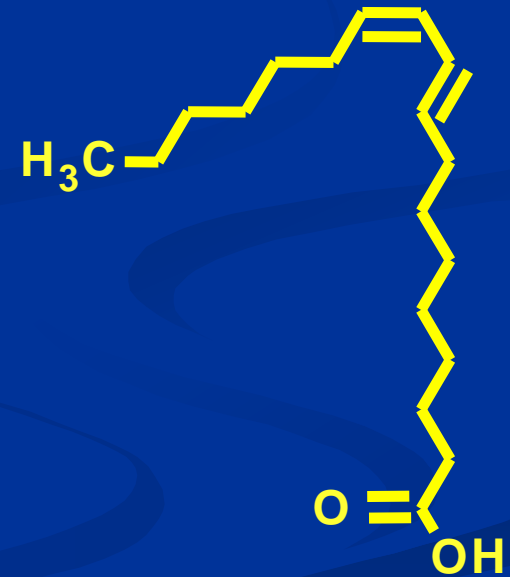
# Dienes



Oleic Acid  
18 carbons  
1 *cis* double bond



Linoleic Acid  
18 carbons  
2 *cis* double bonds



Rumenic Acid  
18 carbons  
1 *cis* double bond  
1 *trans* double bond

# Trans Diene (CLA) Isomers in Milk Fat

Isomer	% of total CLA Isomers
trans-7, cis-9	1.20-8.89
trans-7, trans-9	0.02-2.39
trans-8, cis-10	0.06-1.47
trans-8, trans-10	0.19-0.37
<i>cis-9, trans-11</i>	<i>72.56-91.16</i>
trans-9, trans-11	0.77-2.87
trans-10, cis-12	0.03-1.51
trans-10, trans-12	0.28-1.31
cis-11, trans-13	0.18-4.70
trans-11, cis-13	0.07-8.00
trans-11, trans-13	0.28-4.24
cis-12, trans-14	0.04-0.80
trans-12, trans-14	0.33-2.76
cis,cis isomers	0.06-4.80

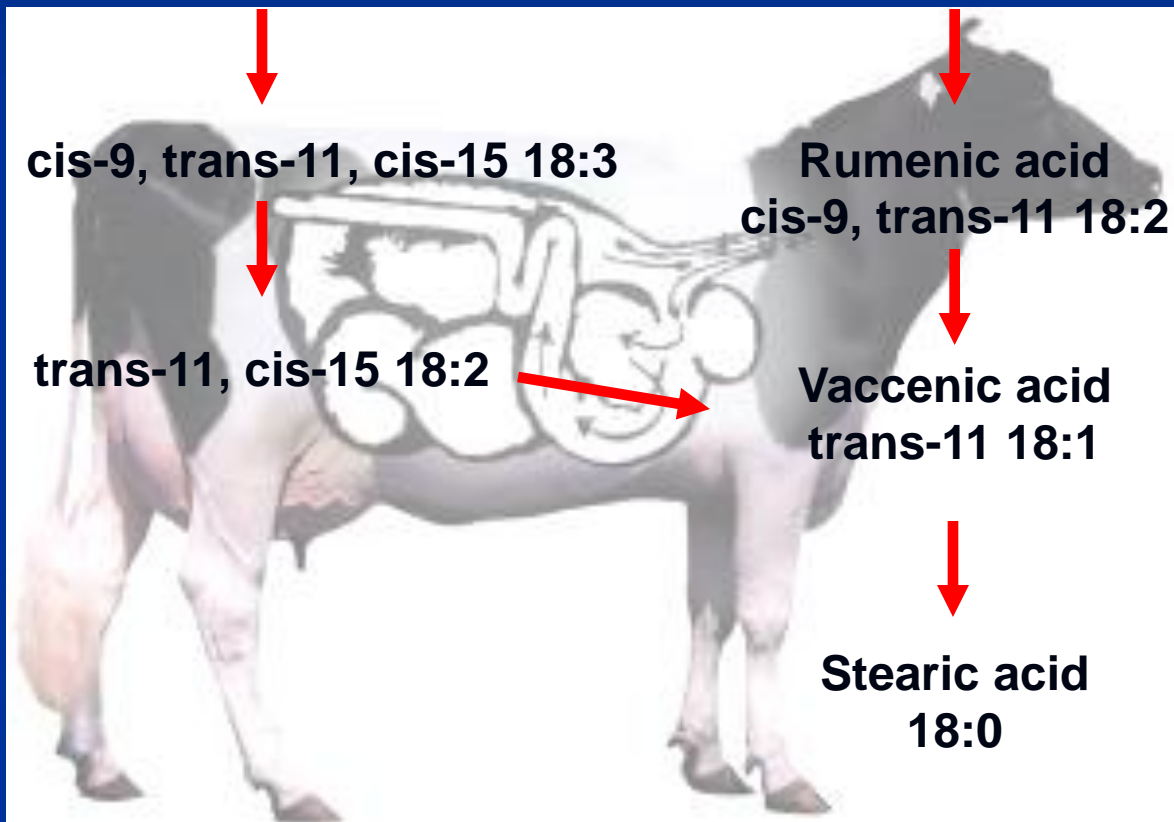


# Synthesis of Natural TFA

**Linolenic acid**  
cis-9, cis-12, cis-15 18:3



**Linoleic acid**  
cis-9, cis-12 18:2



## Extraruminal Tissues

**Rumenic acid**  
cis-9, trans-11 18:2

$\Delta^9$  Desaturase

**Vaccenic acid**  
trans-11 18:1

**Stearic acid**  
18:0

**DIET (e.g., season)**

# Human Conversion of VA to RA

## TISSUES

Cohort	N	Range	Mean
Lactating women	4	0 to 8.6	5.1
Healthy adults	30	0 to >30	19
Man	1	30	

Rumenic acid  
cis-9, trans-11 18:2



$\Delta^9$  Desaturase

Vaccenic acid  
trans-11 18:1

- Conversion of VA to RA is thought to be important

# Overview

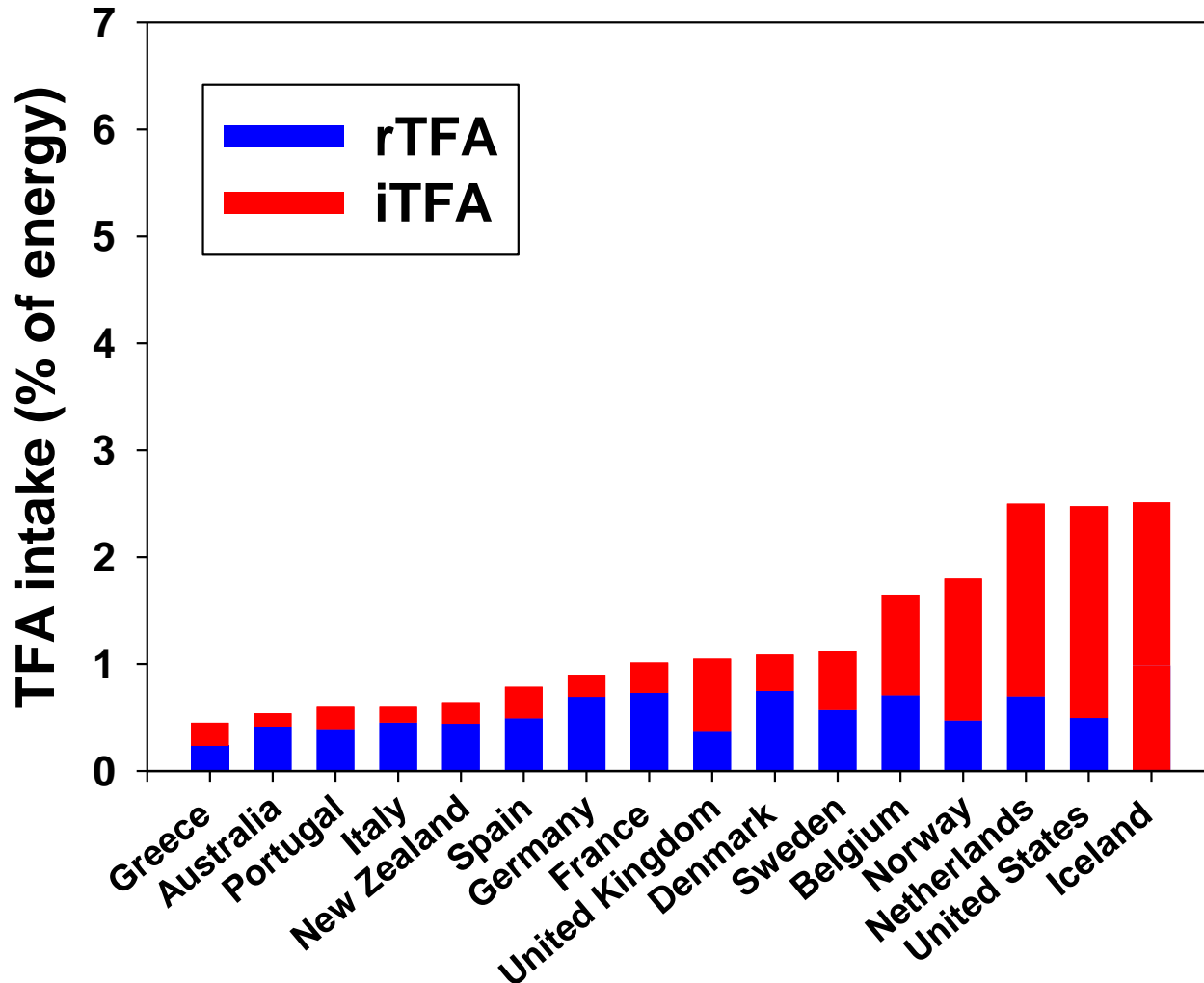
- **What are dairy trans fatty acids?**
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# Epidemiologic Relationship Between TFA Intake and Risk for CHD

Author	Country	Source of TFA	
		Industrial	Natural
Willett, 1993	US	↑	NS
Ascherio, 1994	US	↑	NS
Pietinen, 1997	Finland	↑	↓
Oomen, 2001	Netherlands	NS	NS
Jakobsen, 2008	Denmark	-	NS

All prospective cohort studies except Ascherio (case control).

# Estimates of TFA Intake



# Human Clinical Interventions



# Composition of Butters

(g/100 g butter fat)

	VA Enriched	Control
Vaccenic (Trans-11 18:1)	3.1	0.4
Rumenic (18:2 c9,t11)	1.3	0.3
4:0–12:0	11.7	16.5
Lauric (14:0)	5.9	10.0
Myristic (16:0)	14.7	28.4
Stearic (18:0)	14.4	5.6
Oleic (18:1n-9)	23.4	11.5

Do *trans* fatty acids from industrially produced sources and from natural sources have the same effect on cardiovascular disease risk factors in healthy subjects? Results of the *trans* Fatty Acids Collaboration (TRANSFACT) study<sup>1-4</sup>

	LDL cholesterol (mg/dL)			HDL cholesterol (mg/dL)		
	Industrial	Natural	<i>P</i>	Industrial	Natural	<i>P</i>
<b>Men</b>	87.0	88.7	0.994	58.8	58.2	0.743
<b>Women</b>	89.6	103.1	0.001	73.6	77.8	0.012

- Not controlled feeding
- Gender x Treatment interaction
- No control diet treatment
- Sample size (n=19 men, n=21 women)



Study of the effect of *trans* fatty acids from ruminants on blood lipids and other risk factors for cardiovascular disease<sup>1-3</sup>

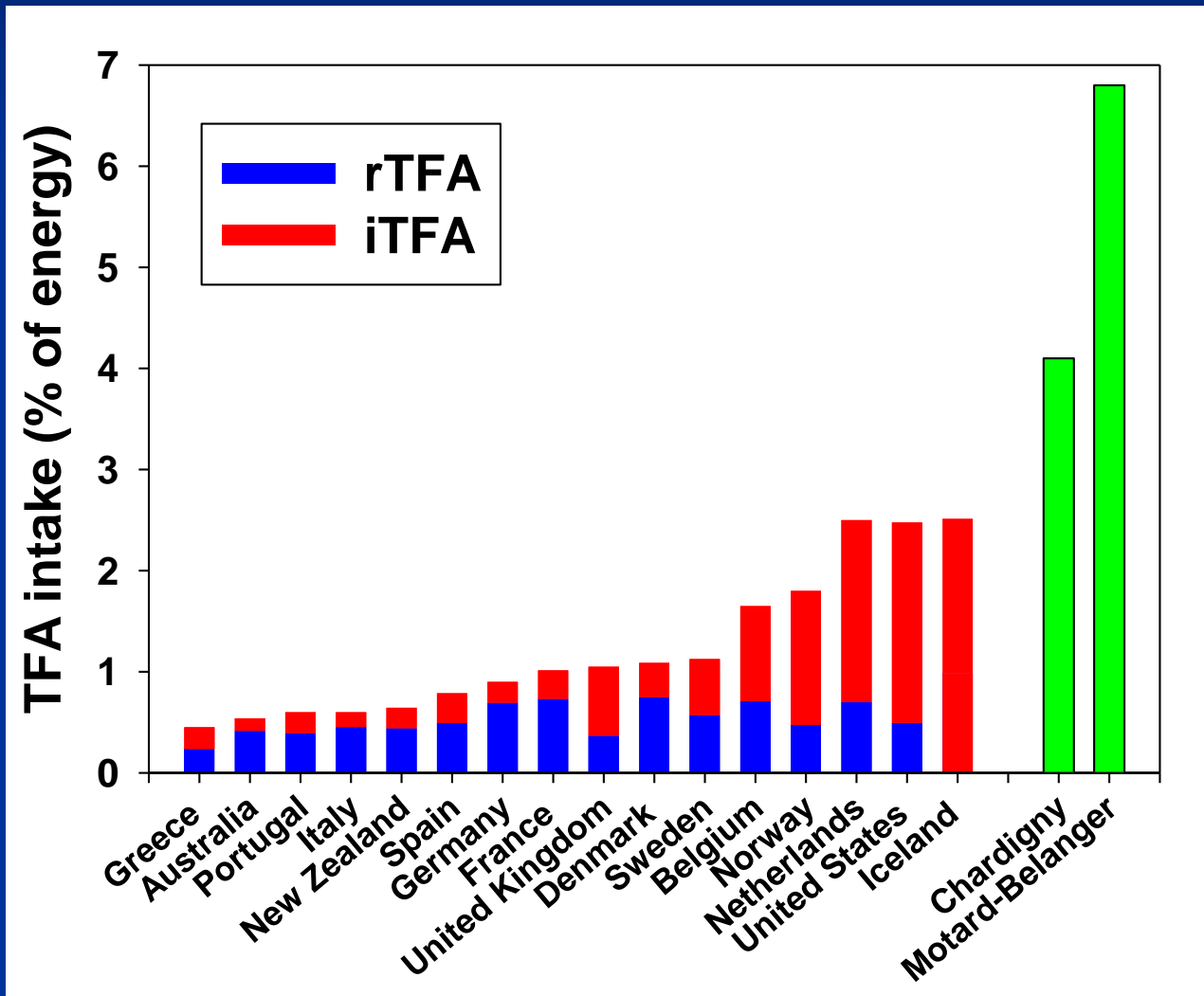
<b>Cholesterol (mg/dL)</b>	<b>Control</b>	<b>High rTFA</b>	<b>iTFA</b>	<b>Results</b>
<b>LDL</b>	126.5	134.2	132.3	•control vs iTFA: NS •rTFA > control
<b>HDL</b>	48.3	47.2	47.6	•NS

- **Sample size (n=38)**

# Comparison of Recent Clinical Studies

	<b>Motard-Belanger</b>	<b>Chardigny</b>
<b>Age (yr)</b>	<b>32.8</b>	<b>27.6</b>
<b>BMI (kg/m<sup>2</sup>)</b>	<b>23.6</b>	<b>22.0</b>
<b>LDL cholesterol (mg/dL)</b>	<b>99.0</b>	<b>95.9</b>
<b>Controlled feeding</b>	<b>Yes</b>	<b>No</b>
<b>Sample size</b>	<b>38</b>	<b>40</b>

# Intake of TFA in Recent Clinical Studies



# Effect of Animal and Industrial *Trans* Fatty Acids on HDL and LDL Cholesterol Levels in Humans – A Quantitative Review

Ingeborg A. Brouwer<sup>1\*</sup>, Anne J Wanders<sup>1,2</sup>, Martijn B. Katan<sup>1</sup>

## *Conclusion*

“Based on this overview we speculate that **all** fatty acids with one or more bonds in the trans configuration raise the ratio of LDL to HDL cholesterol irrespective of their origin or structure.”

# Overview

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# USDA VARA Study

- RCT, double-blind, crossover
- n=120 males & females
- Powered to detect 4.5 mg/dL change in LDL
  - power = 90%
  - alpha = 0.05
- Controlled feeding
  - All meals provided
- Weight maintenance
- 24 days/treatment
- Biomarkers for CVD
- Interesterified TG
- Test fats incorporated into foods (e.g., bakery products, cake icings, sauces, table spreads)

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# CVD Risk Biomarkers

- Total cholesterol, HDL cholesterol, LDL cholesterol, triacylglycerides, Lp(a), apolipoproteins
- Lipoprotein size
- IL-6, hscRP, fibrinogen, factor VII
- ICAM, VCAM, eSelectin
- Glucose, insulin
- *Metabolomics, nutrigenomics*
- *Nutrigenetics*

# Diet Composition

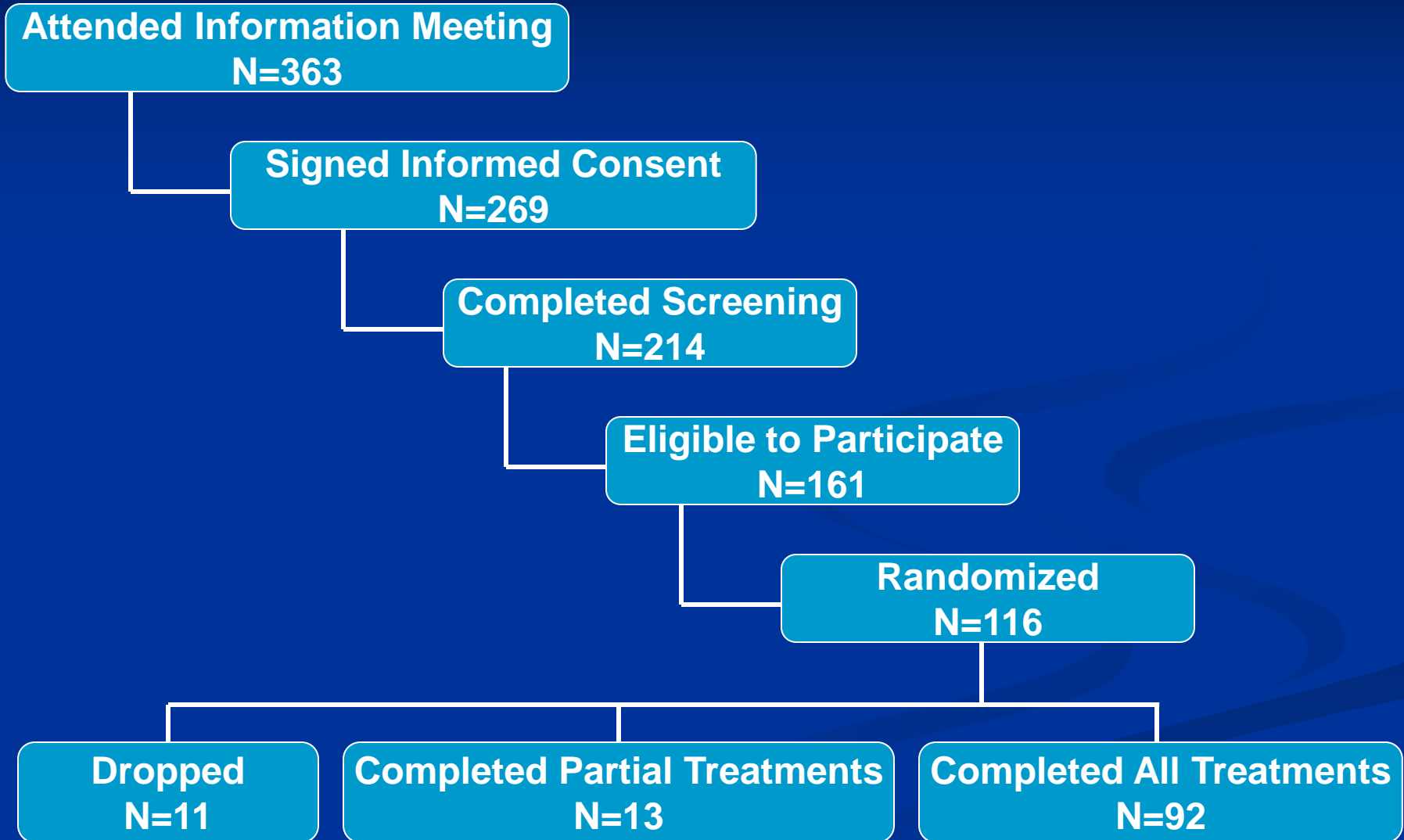
	Treatment			
	Control	3% VA	3% PHVO	1% RA
Protein	17.0	17.0	17.0	17.0
Carbohydrate	49.4	49.4	49.4	49.4
Fat	33.6	33.6	33.6	33.6
L+M+P	7	7	7	7
Oleic	11	11	11	11
Linoleic	5	5	5	5
Linolenic	1	1	1	1
Stearic	7.9	4.9	4.9	6.9
trans 18:1	0.1	3.1 <sup>a</sup>	3.1 <sup>b</sup>	0.1
cis-9, trans-11 CLA	0	0	0	1.0

<sup>a</sup>Vaccenic acid

<sup>b</sup>Mixed isomers from partially hydrogenated vegetable oil



# Recruitment Summary



# Characteristics of Subjects (n=105, 46 Males, 59 Females)

<b>Variable</b>	<b>Mean</b>
<b>Total cholesterol (mg/dL)</b>	<b>192.3</b>
<b>Triglycerides (mg/dL)</b>	<b>102.5</b>
<b>HDL cholesterol (mg/dL)</b>	<b>58.6</b>
<b>LDL cholesterol (mg/dL)</b>	<b>113.6</b>
<b>Body mass index (kg/m<sup>2</sup>)</b>	<b>28.5</b>
<b>Age (yr)</b>	<b>47.2</b>

# Food Preparation



Test fats (color coded)

Examples of special study foods



# Example Menu

## (Sunday 2400 kcal)

Breakfast		Lunch		Dinner		Snack	
Food	Wt	Food	Wt	Food	Wt	Food	Wt
Orange juice	231	Chicken breast	80	Beef	87	Mixed nuts	19
Bacon	19	Pita	87	<i>Beef Gravy</i>	17		
Eggs	48	<i>Mustard Spread</i>	10	<i>Mashed Potatoes</i>	121		
Bread, white	77	Lettuce	24	Broccoli	77		
Applesauce	173	Carrots	34	Lettuce	68		
Sugar	10	Cocoa Brownies	46	Tomatoes	30		
Milk, 1%	232			Cucumber	30		
<i>Fat Spread</i>	14			Salad Dressing	15		
				Bread, Italian	34		
				<i>Yellow Cake</i>	64		
				Strawberries	54		

# Controlled Feeding



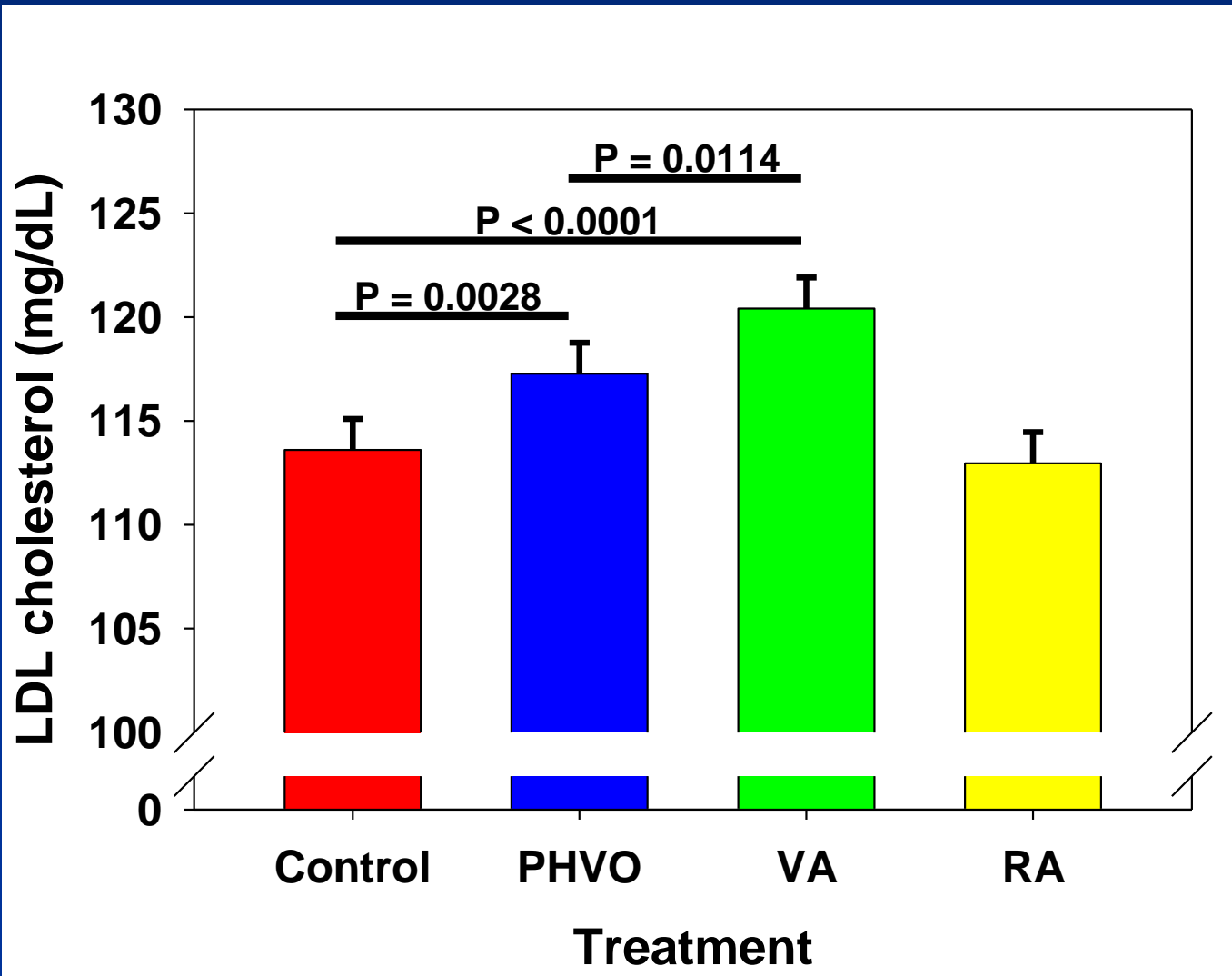
Example meal

Subject eating



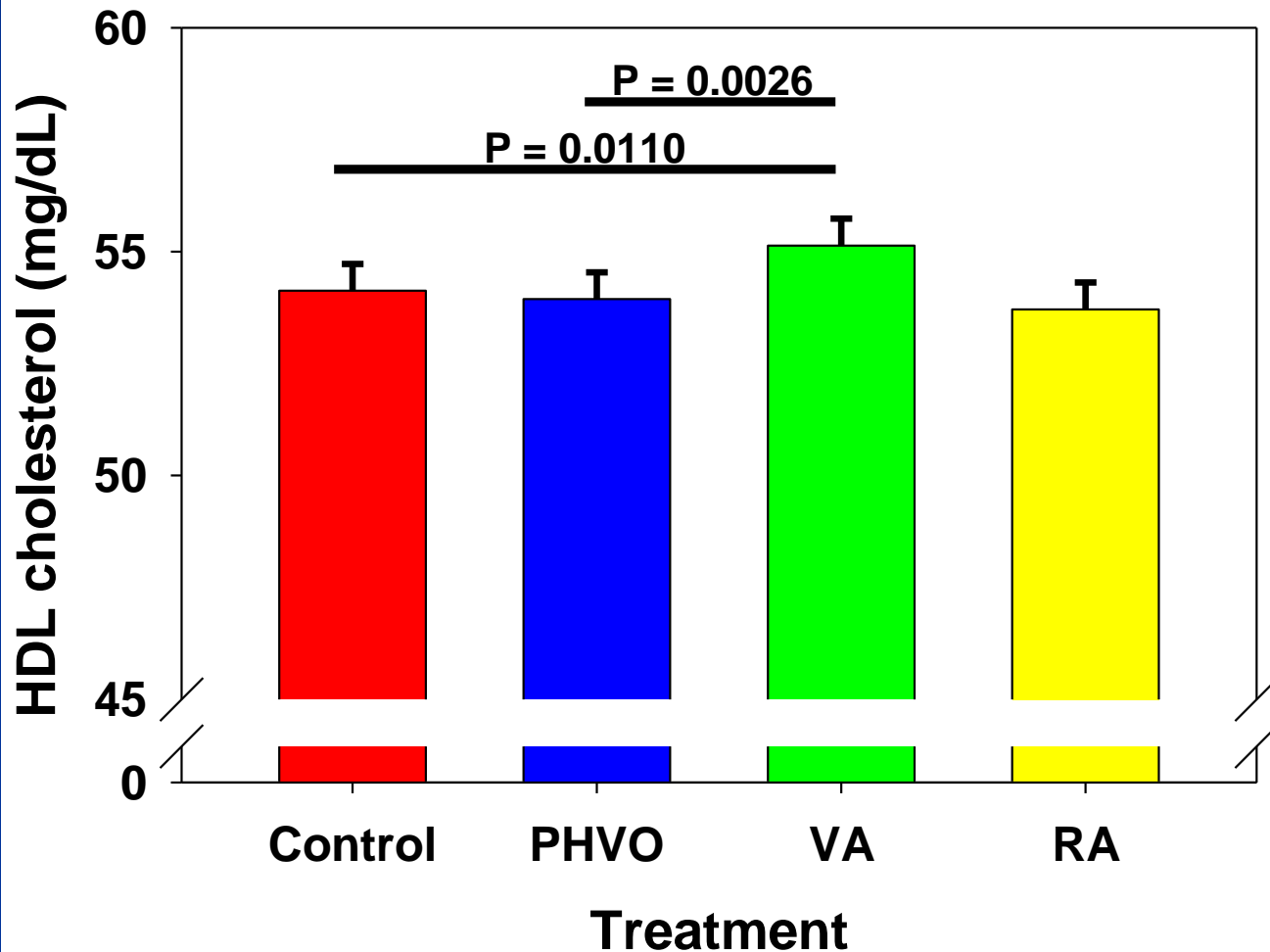
# Preliminary Key Findings

## LDL Cholesterol



# Preliminary Key Findings

## HDL Cholesterol

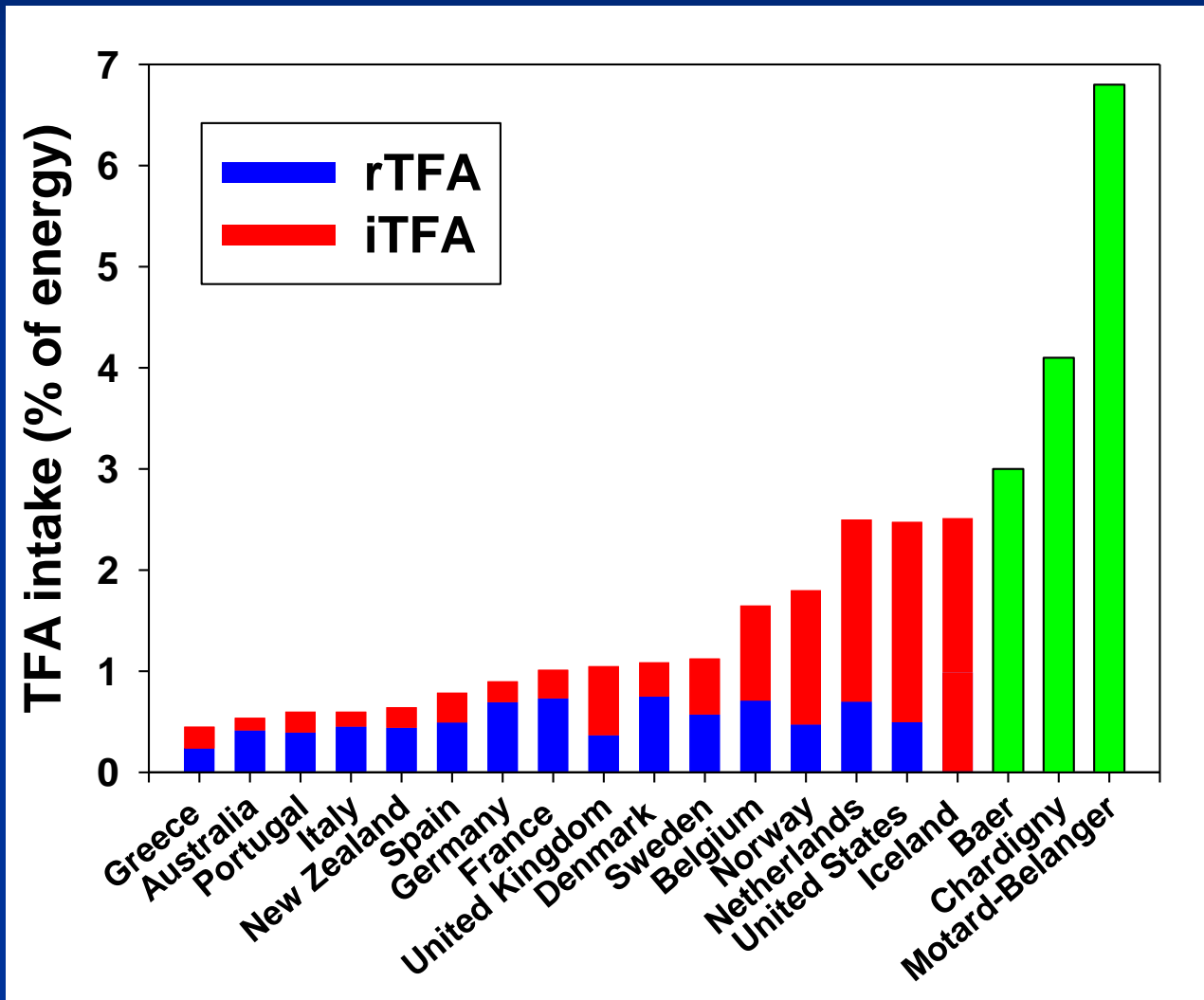


# Comparison of Recent Clinical Studies

	<b>Motard-Belanger</b>	<b>Chardigny</b>	<b>Baer</b>
<b>Age (yr)</b>	32.8	27.6	47.2
<b>BMI (kg/m<sup>2</sup>)</b>	23.6	22.0	28.5
<b>LDL cholesterol (mg/dL)</b>	99.0	95.9	113.6
<b>Controlled feeding</b>	Yes	No	Yes
<b>Sample size</b>	38	40	105



# Intake of TFA in Recent Clinical Studies



# Summary of Recent Clinical Studies



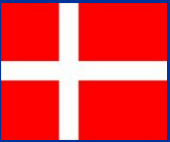
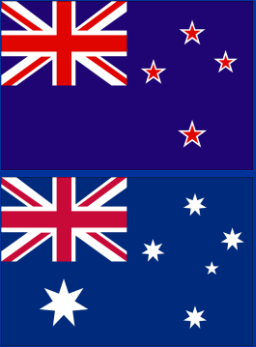
	Motard-Belanger	Chardigny	Baer
<b>LDL Cholesterol</b>			
<b>control vs iTFA</b>	NS	-	iTFA > control
<b>control vs rTFA</b>	rTFA > control	-	rTFA > control
<b>iTFA vs rTFA</b>	NS	rTFA > iTFA (F)	rTFA > iTFA
<b>HDL cholesterol</b>			
<b>control vs iTFA</b>	NS	-	NS
<b>control vs rTFA</b>	NS	-	rTFA > control
<b>iTFA vs rTFA</b>	NS	rTFA > iTFA (F)	rTFA > iTFA

# Questions?

1. Do trans fatty acids from natural and industrial sources have the same impact on coronary heart disease risk?
  - Vaccenic acid raises LDL chol and HDL chol whereas PHVO raises LDL chol without a change in HDL chol
2. Is there a need to regulate them differently?



# Trans Fat Regulations

	Required Labeling	Ingredient Regulations	Dairy Exempt
	If > 0.2 g/serving	Yes (Local)	No
	If > 0.5 g/serving	Yes (Local)	No/Yes
	No	Yes (National)	
	No	No	



# Acknowledgments

## ■ USDA, ARS

- Carolyn Chung
- Evelyn Lashley
- Sarah Gebauer
- Nancy Rozgony
- Theresa Henderson
- Emily Yu
- Kathleen Sanders

## ■ NDC

- Pete Huth
- Anne Kurilich
- Susan Zaripheh

## ■ Nestle

- Frédéric Destailats
- Zephirin Mouloungui
- Laure Candy
- Jean-Baptiste Bezelgues
- Fabiola Dionisi