

**FOOD** FOR  
**HEALTH**  
**IRELAND**



[www.fhi.ie](http://www.fhi.ie)

# THE DAIRY FOOD MATRIX

## A Nutrition Perspective:

### Health impacts beyond individual nutrients

**Dr Aileen O'Connor**

**Food for Health Ireland**

**University College Dublin**



# Overview

- **Background - FHI**
- **Dairy foods and health – evidence**
- **Dairy food matrix effects**
- **Dairy fat matrix study**
- **Current work in FHI 3**





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# WHAT IS FHI?

## Partnership between:

- Public Research Organisations
- Irish food companies (Kerry, Glanbia, Carbery & Dairygold)

## Funded by:

- Enterprise Ireland and Industry
- Third 5-year term, since Jan 2019



## Industry-led research agenda:

- Development of food and food ingredients with potential health benefits
- Targeting – Infant nutrition, healthy ageing and performance nutrition markets

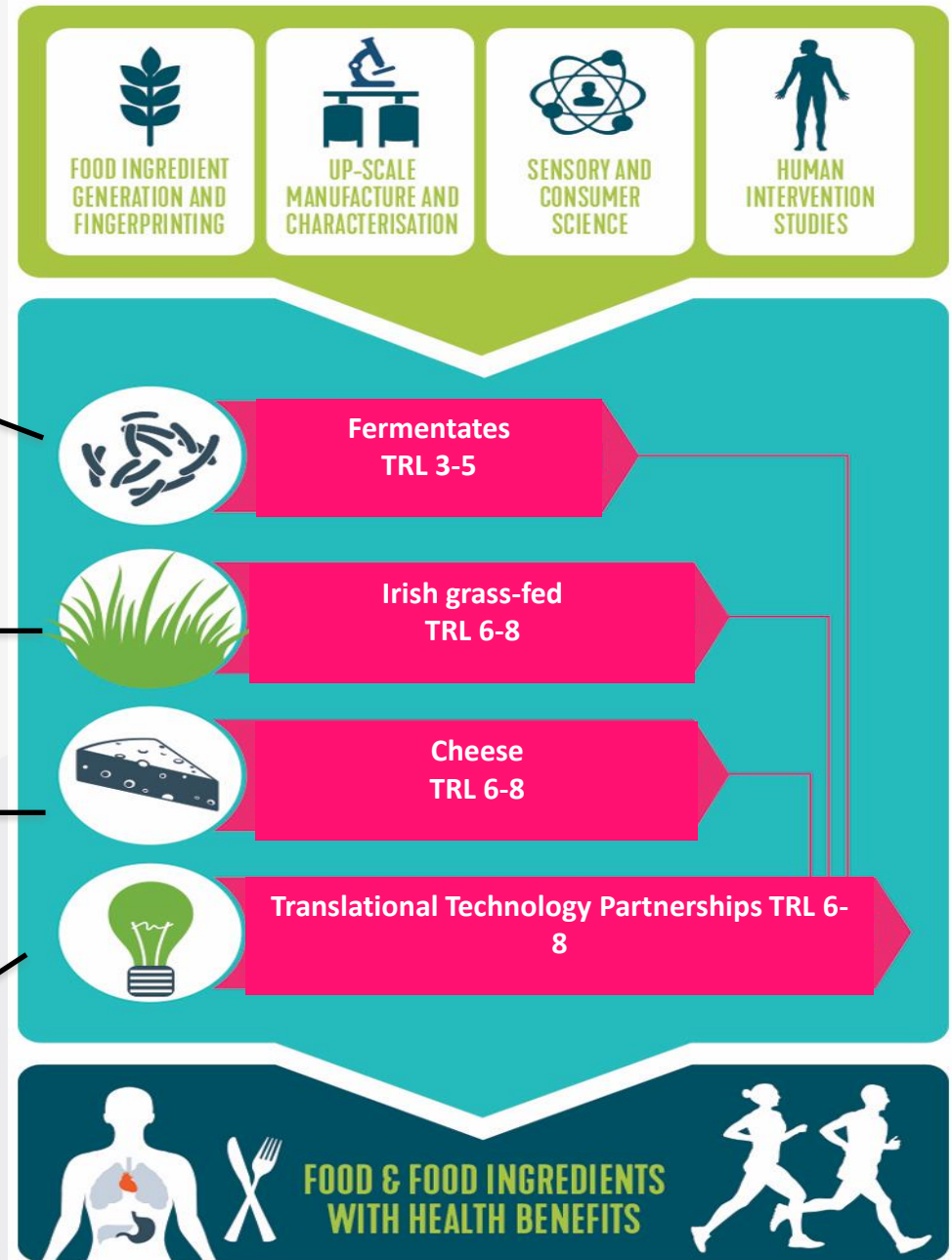
# FHI 3 PROGRAMME

Enhance gut health & nutrient absorption, reduce gut inflammation

Authenticity and provenance

Benefits to cardiovascular function

Bringing the science closer to market





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# Saturated fat and CHD risk - debate

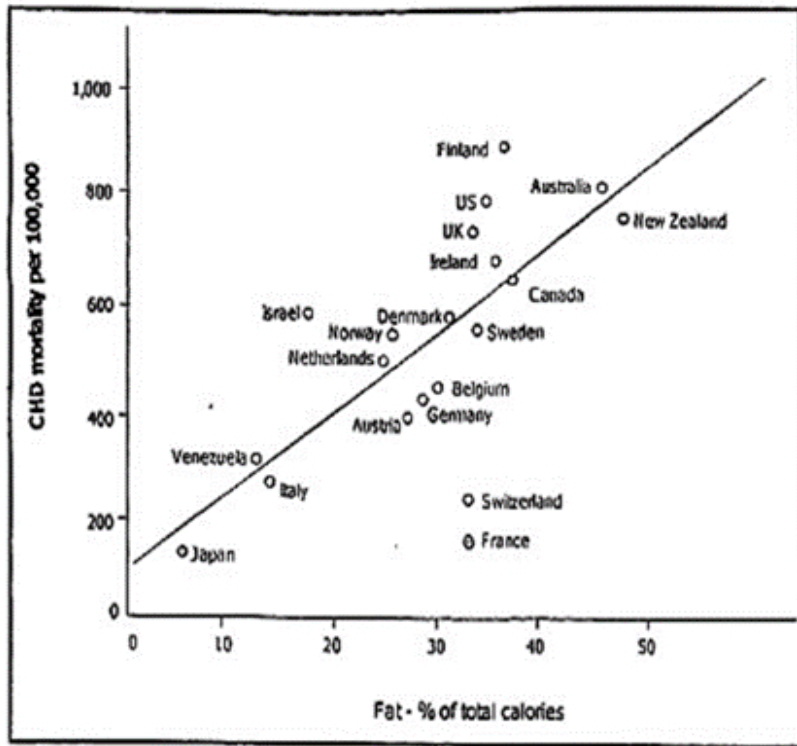


Figure 1. Dietary consumption of fat and Coronary Heart Disease Mortality in Various Countries.

Ancel Keys

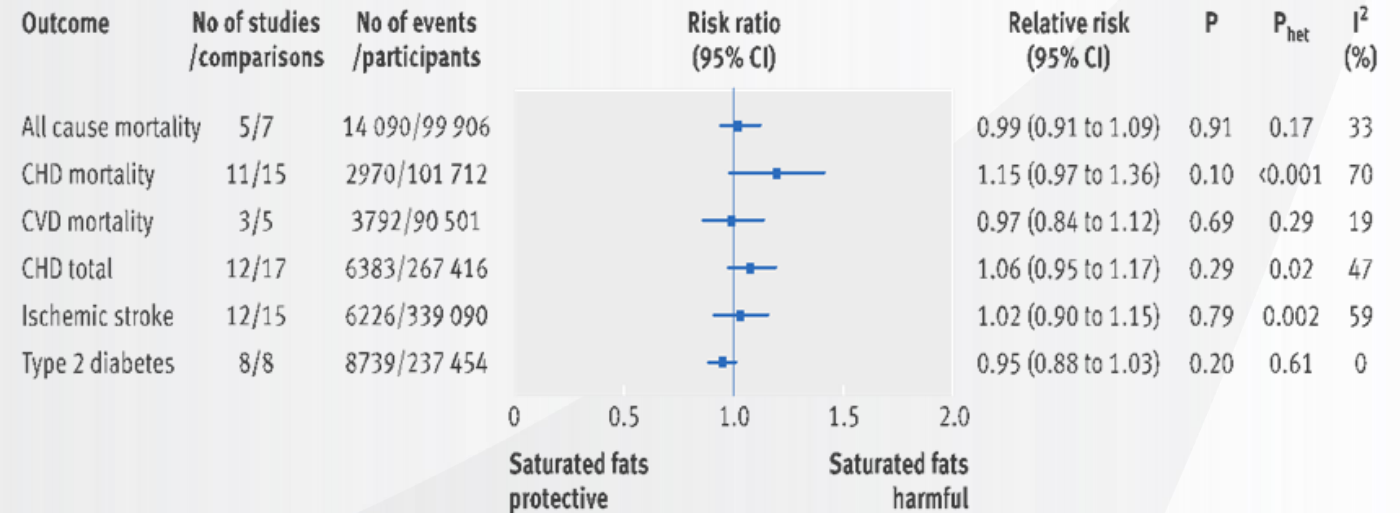
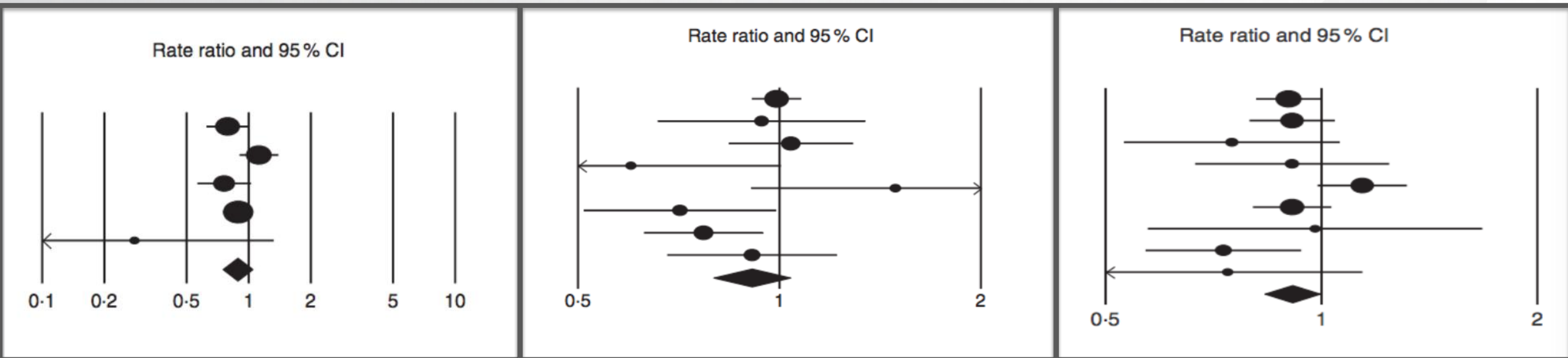


Fig 2 | Summary most adjusted relative risks for saturated fat intake and all cause mortality, CHD mortality, CVD mortality, total CHD, ischemic stroke, and type 2 diabetes. All effect estimates are from random effects analyses. P value is for Z test of no overall association between exposure and outcome; P<sub>het</sub> is for test of no differences in association measure among studies; I<sup>2</sup> is proportion of total variation in study estimates from heterogeneity rather than sampling error

De Souza

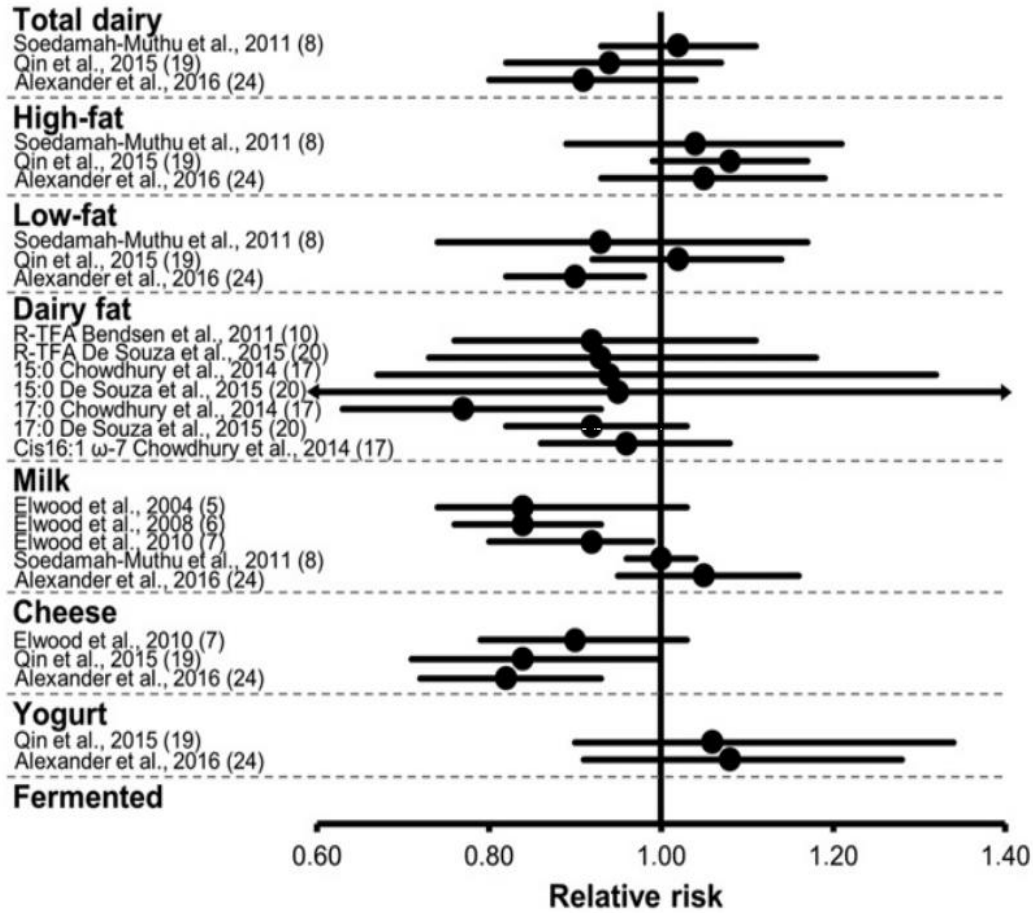


# Alexander (2016, BJN) Meta-analysis of dairy intake and risk of CVD, CHD and Stroke:

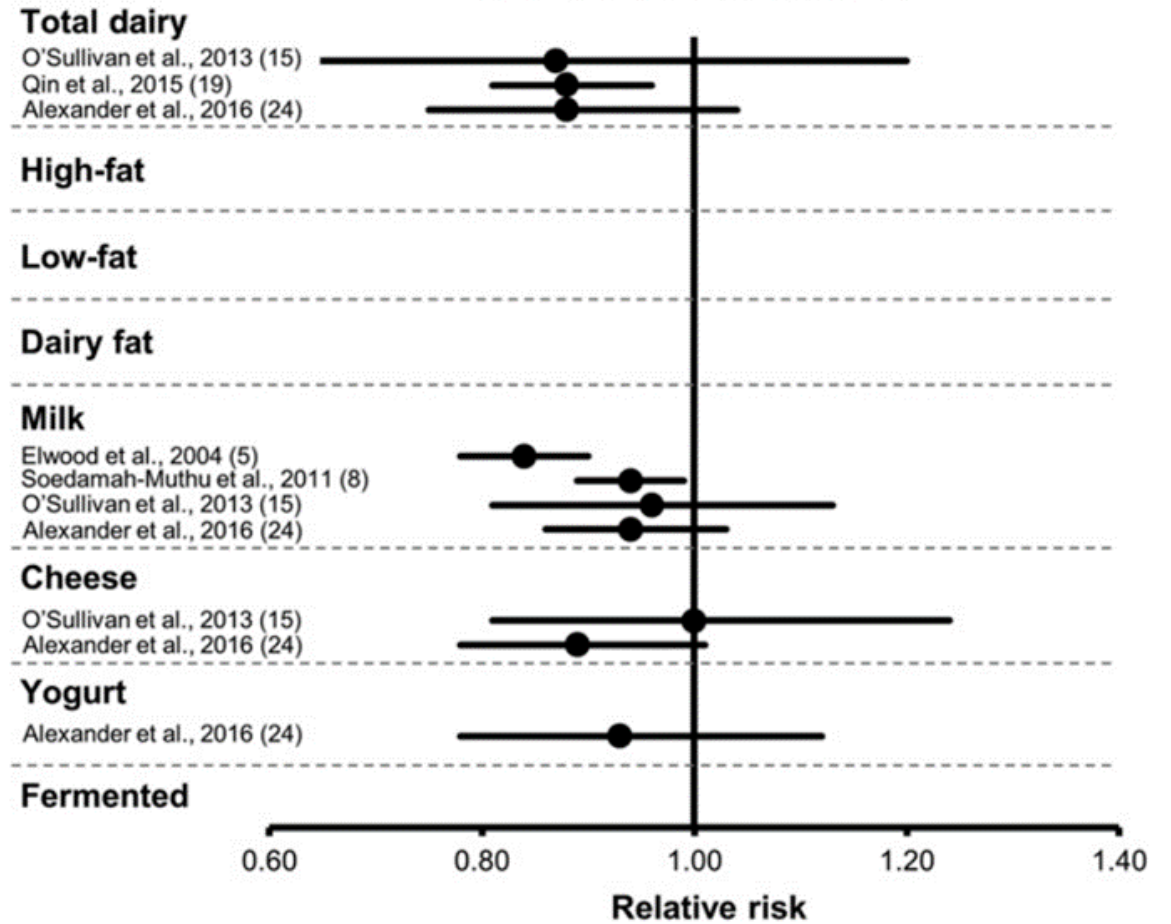


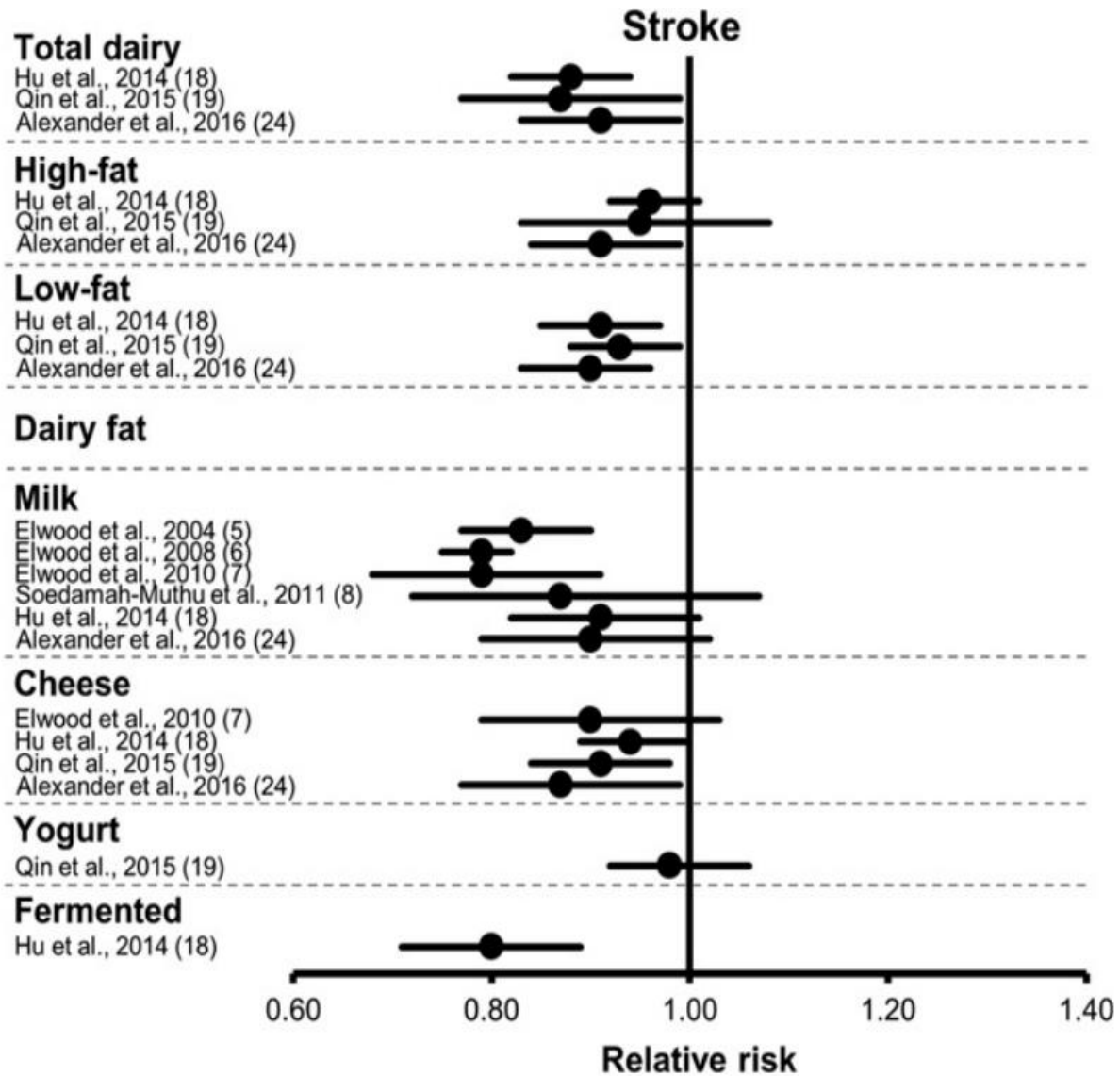
31 unique cohort studies – overall, no association (CHD and stroke). Possibly reduced risk for CVD but more detailed data is required on intakes for dose-response analysis

### Coronary artery disease



### Cardiovascular disease







# Dairy Consumption and Risk of Stroke: A Systematic Review and Updated Dose–Response Meta-Analysis of Prospective Cohort Studies

Janette de Goede, PhD; Sabita S. Soedamah-Muthu, PhD; An Pan, PhD; Lieke Gijsbers, MSc; Johanna M. Geleijnse, PhD

Current Nutrition Reports (2018) 7:171–182

<https://doi.org/10.1007/s13668-018-0253-y>

CARDIOVASCULAR DISEASE (JHY WU, SECTION EDITOR)



## Dairy Consumption and Cardiometabolic Diseases: Systematic Review and Updated Meta-Analyses of Prospective Cohort Studies

Sabita S. Soedamah-Muthu<sup>1,2</sup> • Janette de Goede<sup>3</sup>

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# MOVING BEYOND SINGLE NUTRIENTS

- Traditionally, study of nutrients and health - a 'reductionist' approach
- Does not allow for the study of a '**food matrix**' effect



- Examples from almonds demonstrate that the degree of chewing affects the energy extracted
- Also affects protein digestion – can impact allergenicity



- Carotenoids in carrots – raw pieces vs homogenised– show large differences in the bioavailability (3%, vs 21%) <sup>(1)</sup>
- Further enhanced to 39%, when cooked with oil

- Wheat matrix effect on the tolerance of baked milk on IgE cows' milk allergy <sup>(2)</sup>



1. Hedren et al, (2002) Eur J Clin Nutr,
2. Sopo et al, (2016) Allergol Immunopathol

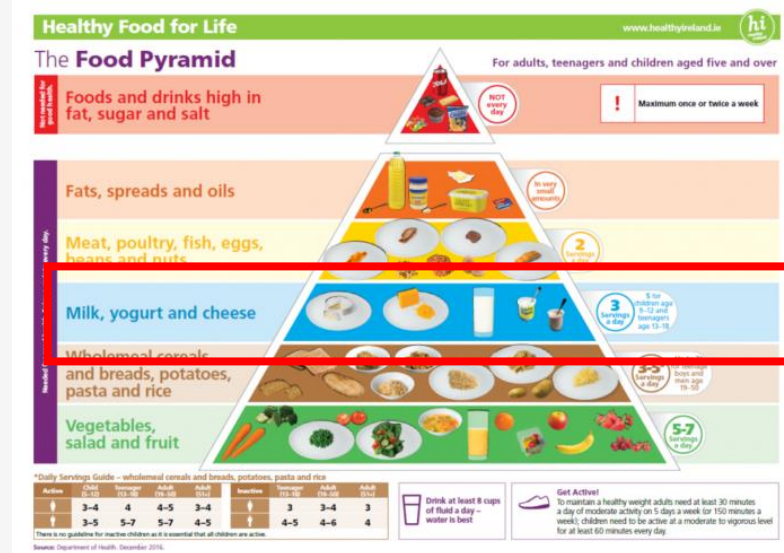


# WHAT IS THE 'DAIRY MATRIX'?

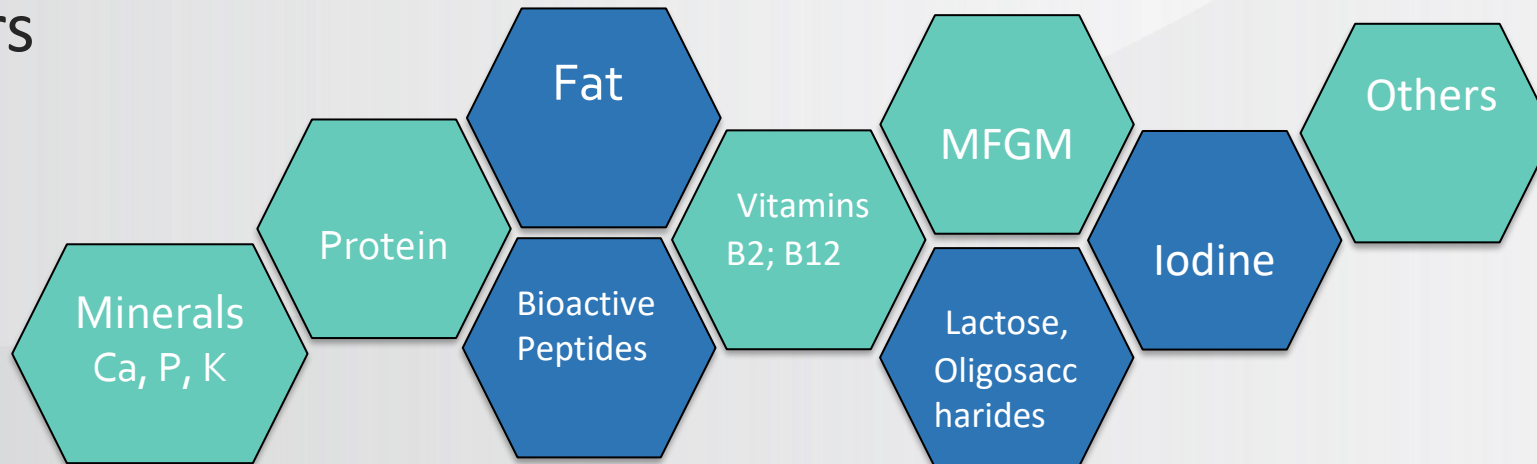
'Foods consist of a large number of different nutrients that are contained in a complex structure. The nature of the **food structure and the nutrients therein** (i.e., the food matrix) will determine the nutrient **digestion and absorption**, thereby altering the **overall nutritional properties** of the food'

Thorning *et al*, (2017) AJCN

# DAIRY FOODS ARE NOT ALL THE SAME:



- The 'Dairy' shelf : **' Milk, cheese, and yoghurt'**
- **Even this is overly simplistic** - different types of milk, cheeses and yoghurt
- The matrices within these are varied; protein, peptides, fat content, sugars



## NUTRIENTS IN DAIRY FOOD

### **Vitamin B12**

Keeps body's nerve and blood cells healthy, helps make genetic material in all cells

### **Protein**

Provides structure, growth and maintenance for the body, carries out chemical reactions, acts as messengers

### **Calcium**

Plays essential role in muscle contraction, bone and teeth development, blood clotting, transmission, fluid balance

### **Potassium**

Regulates fluid balance, muscle contraction and nerve signals

### **Saturated Fat and Salt**

Often considered 'nutrients of concern' in Western diets. Overconsumption has been linked to a range of detrimental health impacts

### **Phosphorous**

Component in bones, teeth, DNA and RNA and helps in activation of enzymes





## The Food Pyramid

For adults, teenagers and children aged five and over

Not treated for good health.

Foods and drinks high in fat, sugar and salt



NOT every day



Maximum once or twice a week

Fats, spreads and oils

in very small amounts

Meat, poultry, fish, eggs, beans and nuts

2 Servings a day

Milk, yogurt and cheese

3 Servings a day

5 for children age 9-12 and teenagers age 13-18

Wholemeal cereals and breads, potatoes, pasta and rice

3-5\* Servings a day

Up to 7\* for teenage boys and men age 19-50

Vegetables, salad and fruit

5-7 Servings a day

\*Daily Servings Guide - wholemeal cereals and breads, potatoes, pasta and rice

Active	Child (5-12)	Teenager (13-20)	Adult (16-50)	Adult (51+)	Inactive	Teenager (13-20)	Adult (16-50)	Adult (51+)
	3-4	4	4-5	3-4		3	3-4	3
	3-5	5-7	5-7	4-5		4-5	4-6	4

There is no guideline for inactive children as it is essential that all children are active.



Drink at least 8 cups of fluid a day - water is best



Get Active!

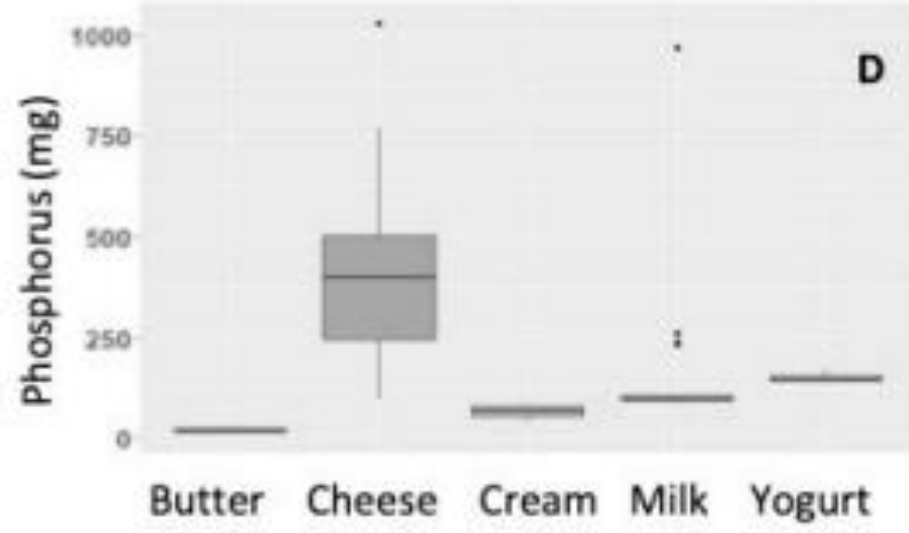
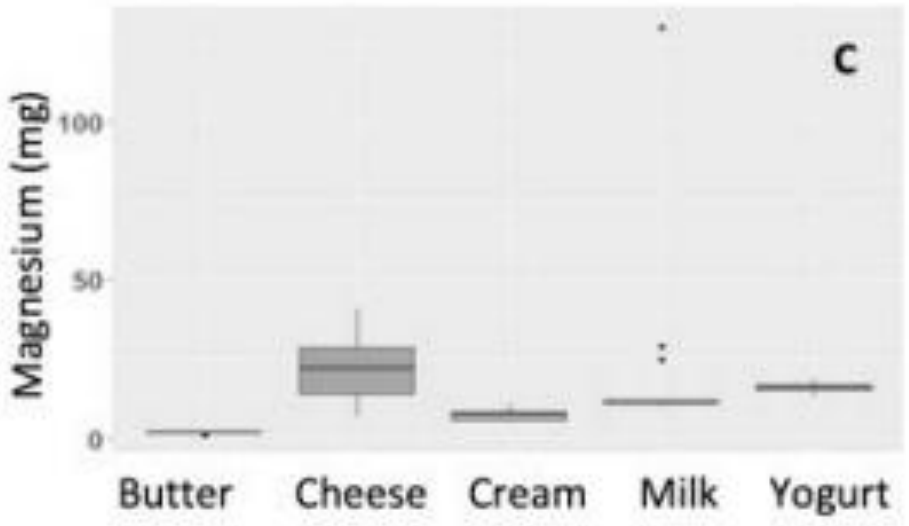
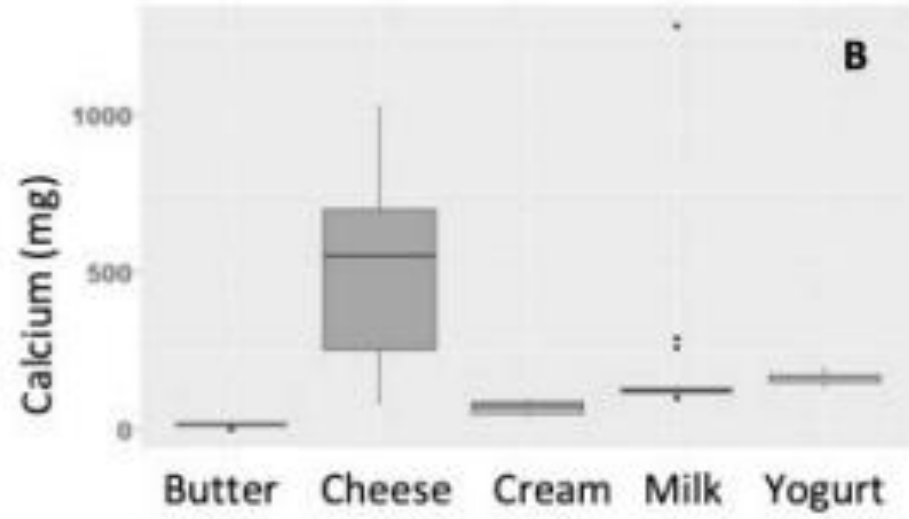
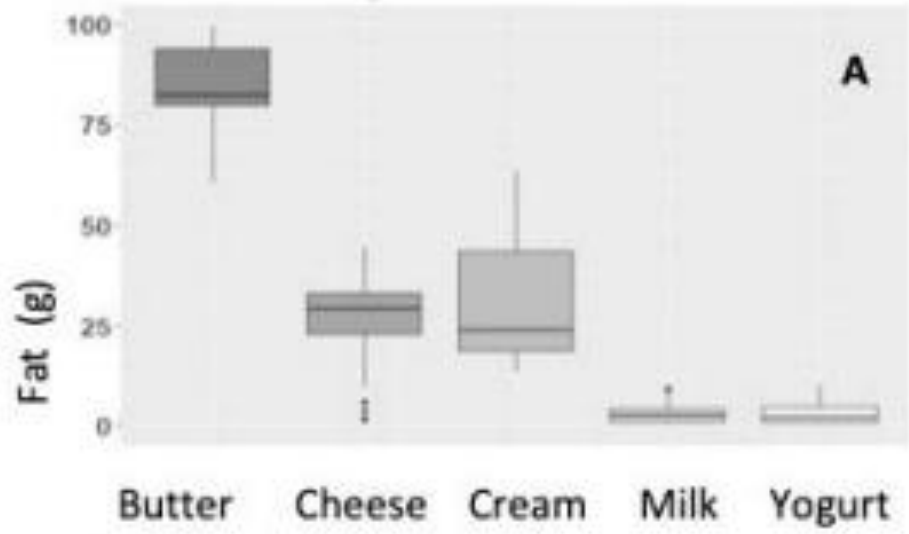
To maintain a healthy weight adults need at least 30 minutes of moderate activity on 5 days a week for 150 minutes a week; children need to be active at a moderate to vigorous level for at least 60 minutes every day.





*Review*  
**Dairy Consumption and Metabolic Health**

Claire M. Timon <sup>1</sup>, Aileen O'Connor <sup>2,3</sup>, Nupur Bhargava <sup>2,3</sup>, Eileen R. Gibney <sup>2,3,\*</sup> and Emma L. Feeney <sup>2,3</sup>



**TABLE 2**Bioactive components and supramolecular structures in different dairy products<sup>1</sup>

	Calcium, mg/100 g	Phosphorus, mg/100 g	MFGM, <sup>2</sup> mg/100 g	Protein, <sup>3</sup> g/100 g, type	Fermented	Fat structure <sup>4</sup>	Protein network
Cheese <sup>5</sup> (25% fat)	659	510	150	23.2, Casein	Yes	MFG/aggregates/free fat	Solid/viscoelastic
Milk (skimmed, 0.5% fat)	124	97	15	3.5, Whey/casein	No	Tiny native MFG/potential MFGM fragments	Liquid
Milk (whole, 3.5% fat)	116	93	35	3.4, Whey/casein	No	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Liquid
Yogurt (1.5% fat)	136	99	15	4.1, Whey/casein	Yes	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Gel/viscoelastic
Cream (38% fat)	67	57	200	2, —	No	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Liquid
Butter	15	24	—	<1, —	No/yes <sup>6</sup>	Continuous fat phase (water-in-oil emulsion)/MFGM-residue traces	—

<sup>1</sup> All values are approximate amounts. MFG, milk-fat globule; MFGM, milk-fat globule membrane.

<sup>2</sup> General estimation on the basis of Dewettinck et al. (11) and Conway et al. (12).

<sup>3</sup> According to food-composition tables from The Technical University of Denmark (13).

<sup>4</sup> General estimation on the basis of Michalski (14) and Michalski et al. (15) and references therein.

<sup>5</sup> Semihard Danbo type, as a point example among many different cheese types.

<sup>6</sup> Depends on the production method used. With indirect biological acidification, starter culture is added to the butter after churning.



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# FHI – Cheese Matrix Study:

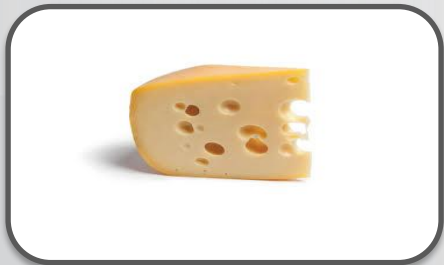
- Hypothesis – that fat needs to be within the cheese matrix to see effects

**Inclusion Criteria:** Over 50's population, with BMI of 25 or over

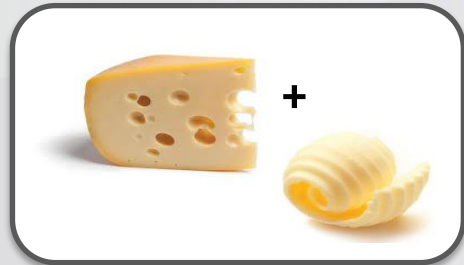
**Intervention:** 42g fat in 3 matrices (cheese, butter or reduced fat cheese) for 6w

**Outcomes:** Markers of heart health (LDL-C, HDL-C, key inflammatory cytokines)

A



B



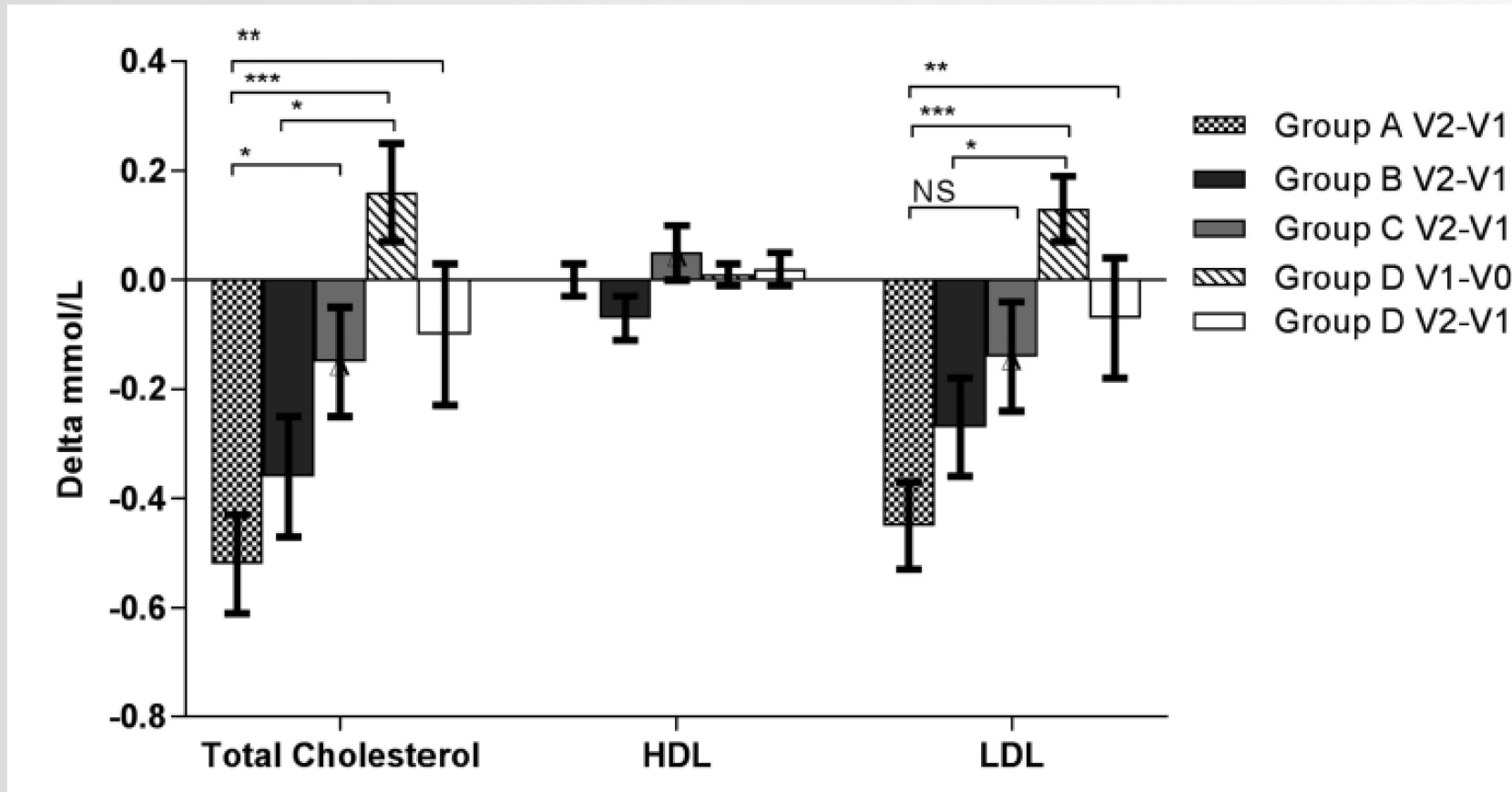
C



D



# Cheese Matrix Study – Lipids ‘Stepwise Matrix Effect’



- Significant differences in reduction in total cholesterol and LDL-C
- Greatest reduction when all fat ‘in the matrix’

Figure 1. Change in lipid profiles following dietary intervention

n=127 (Per Protocol Group)

Feeney *et al.*, (2018) *Am J Clin Nutr*



# Cheese Matrix Study – Weight, Glucose and CRP:

## Delta values weight, BMI, BF %

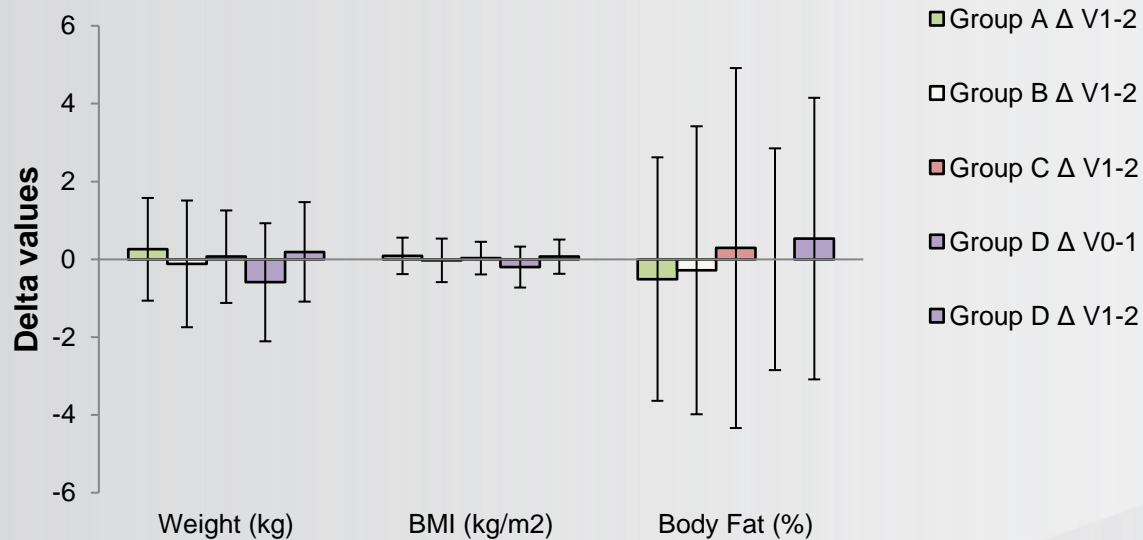


Figure 2. Change in anthropometry following dietary intervention,

n=127 (Per Protocol Group)

Feeney *et al.*, (2018) *Am J Clin Nutr*

## Delta values glucose, hsCRP

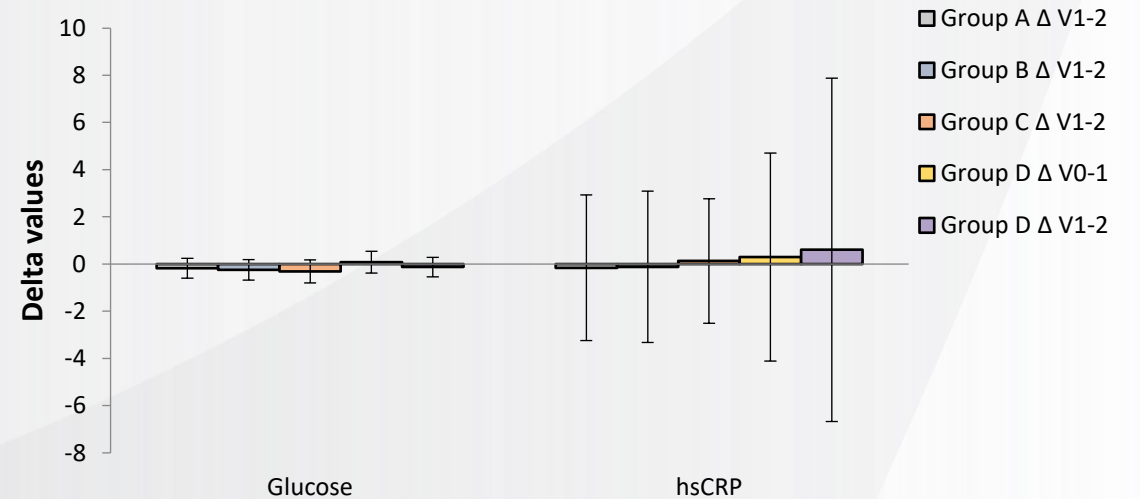
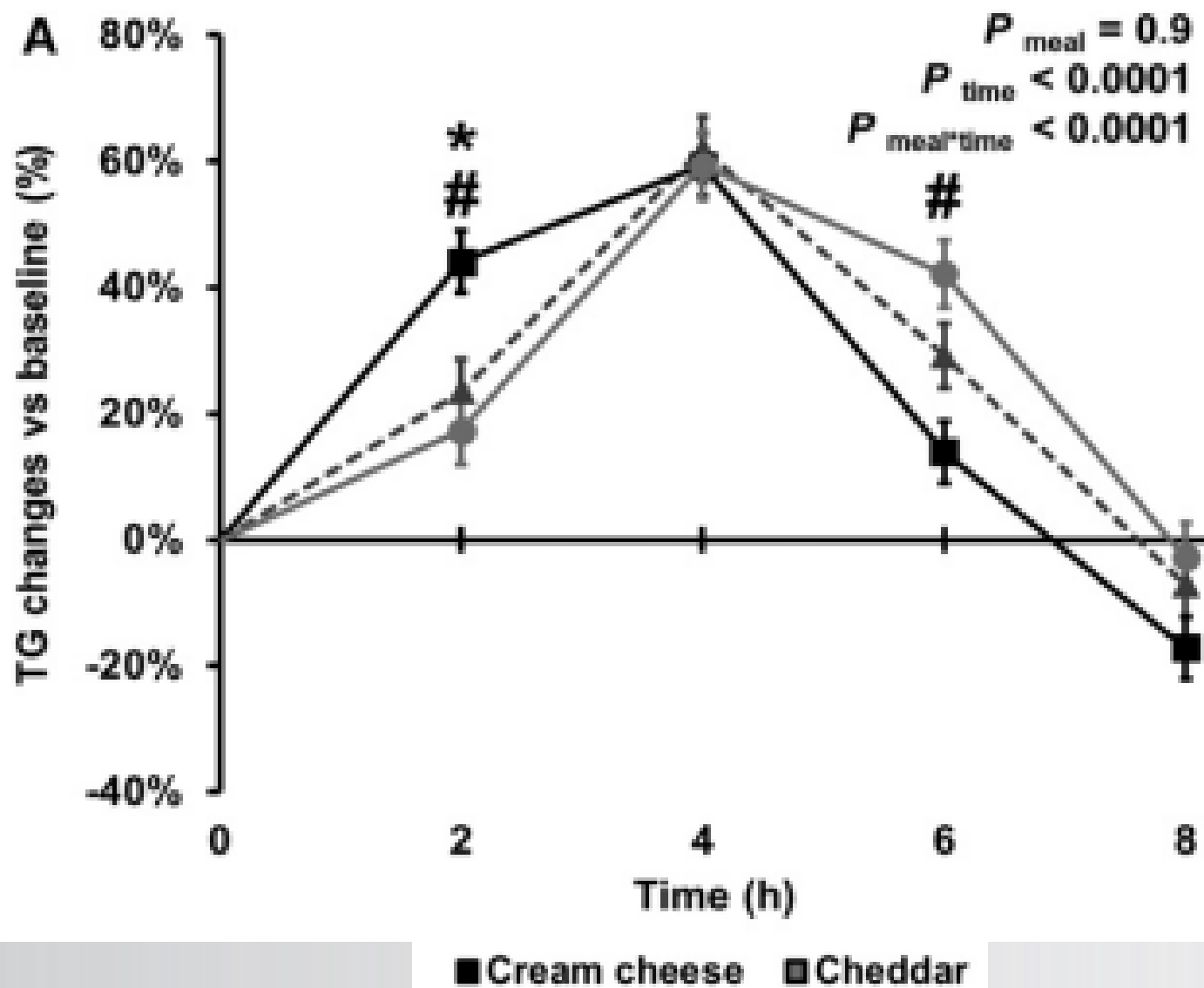


Figure 3. Change in glucose, hsCRP

# Differential impact of the cheese matrix on the postprandial lipid response: a randomized, crossover, controlled trial

Jean-Philippe Drouin-Chartier,<sup>1</sup> André J Tremblay,<sup>1</sup> Julie Maltais-Giguère,<sup>1</sup> Amélie Charest,<sup>1</sup> Léa Guinot,<sup>1,2</sup> Laurie-Eve Rioux,<sup>1,2</sup> Steve Labrie,<sup>1,2</sup> Michel Britten,<sup>4</sup> Benoît Lamarche,<sup>1,2</sup> Sylvie L Turgeon,<sup>1,2</sup> and Patrick Couture<sup>1-4</sup>



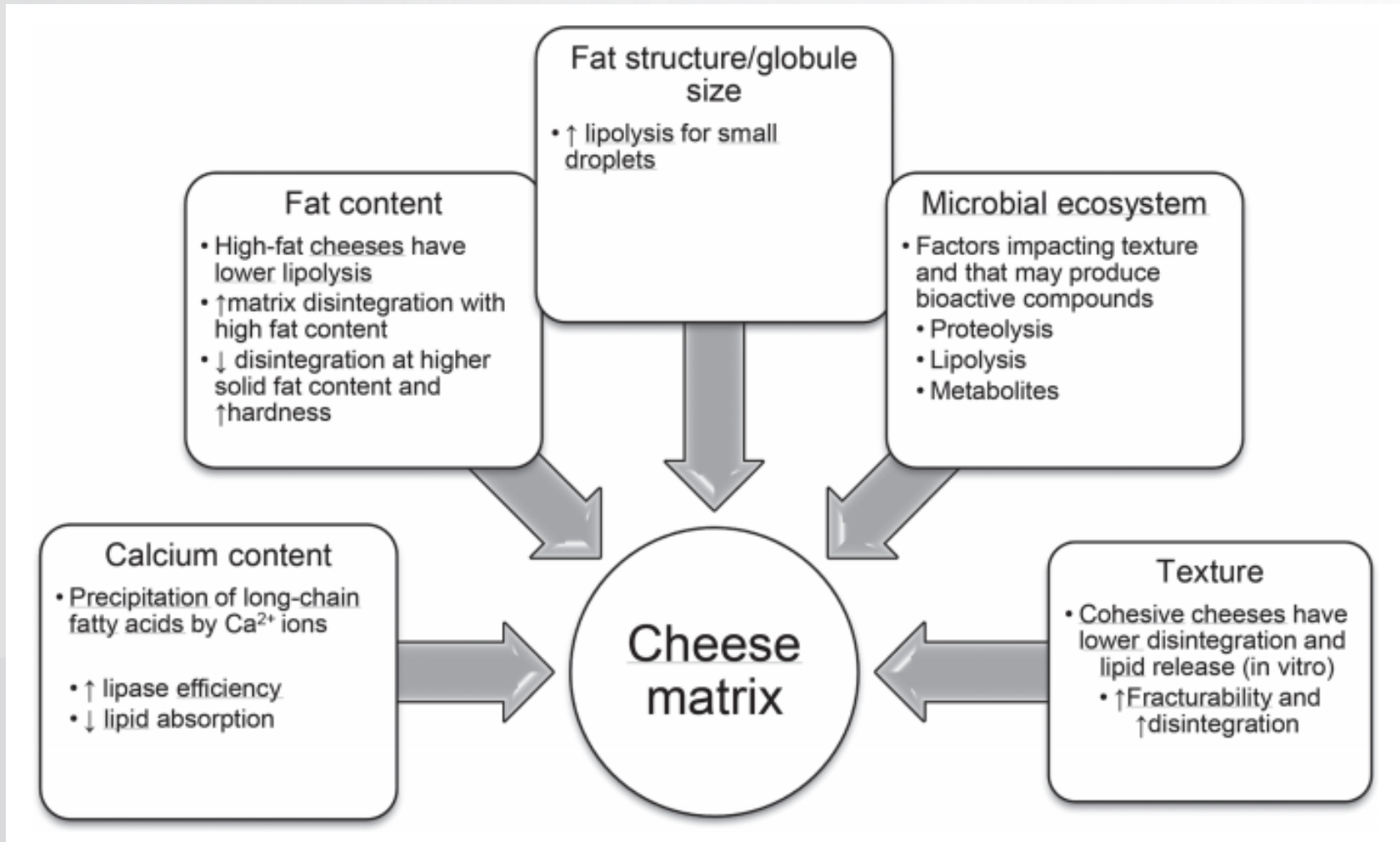
- **4 hr** – Similar increases of triglyceride (TRIG) concentrations
- **2 hr** – TRIG response from cream cheese greater than butter and cheddar
- **6 hr** – cream cheese response significantly reduced compared with cheddar
- Cheese matrix modulates impact of dairy fat on PP lipemia

## Symposium review: The dairy matrix—Bioaccessibility and bioavailability of nutrients and physiological effects\*

Sylvie L. Turgeon<sup>1,2</sup> and Guillaume Brisson<sup>1,2</sup>

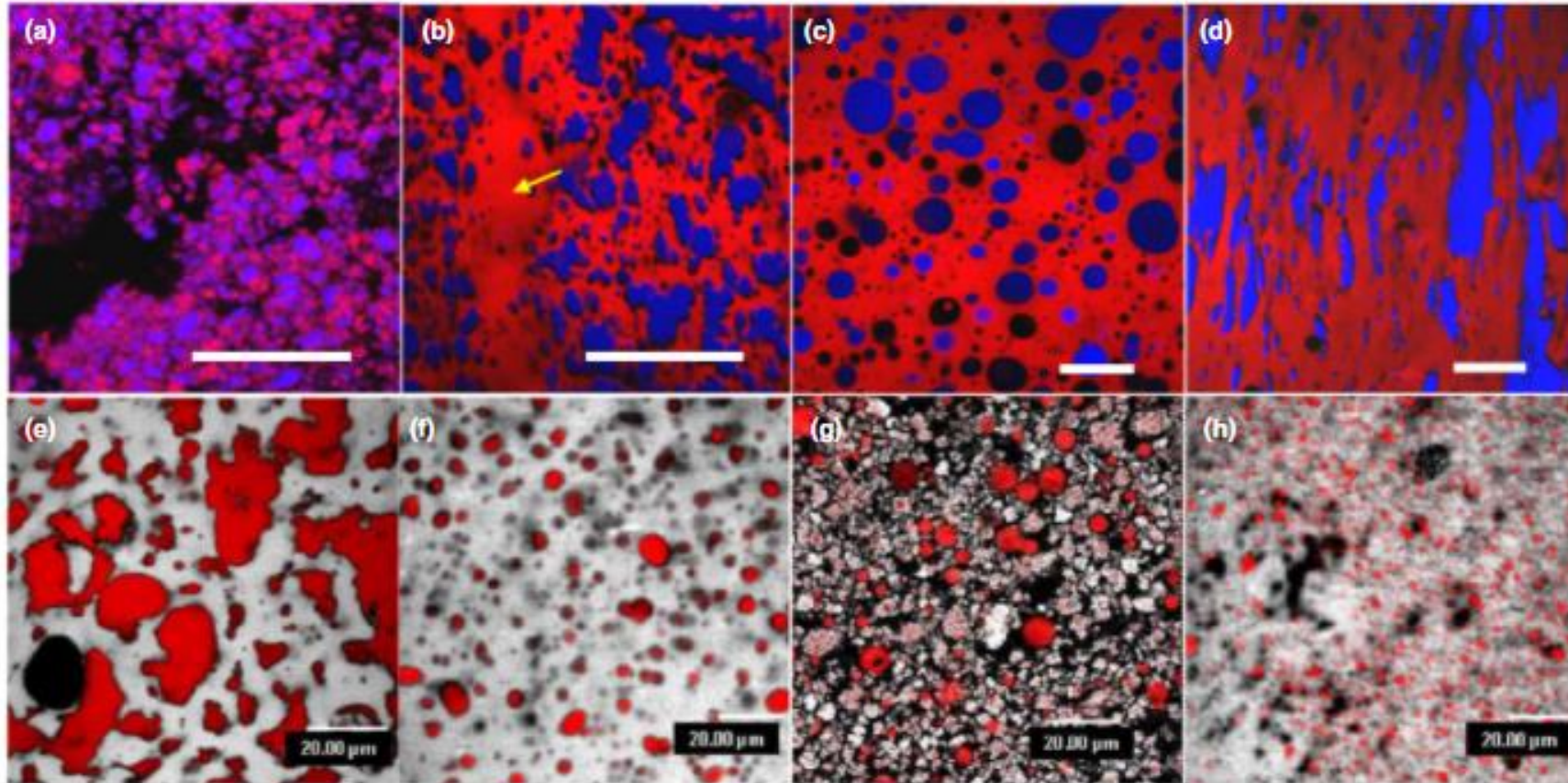
<sup>1</sup>Dairy Science and Technology Research Centre (STELA), University Laval, Quebec City, QC, G1V 0A6, Canada

<sup>2</sup>Institute of Nutrition and Functional Foods (INAF), University Laval, Quebec City, QC, G1V 0A6, Canada





# Cheese structure



**Figure 1** Microstructure of various cheese types: (a) Cream cheese, (b) Cheddar cheese; arrow shows curd granule junction, (c) Processed Cheese, (d) Mozzarella cheese, (e) Emmental cheese, (f) Camembert cheese, (g) whipped cream cheese and (h) soft cheese made with ultrafiltration technology. Micrographs (a) to (d) are adapted from Auty et al. (2001); the protein phase appears red while the fat phase appears blue; scale bar 25  $\mu\text{m}$ . Micrographs (e) to (h) are adapted from Lopez (2005); fat is coloured in red, proteins are in grey levels. Black areas correspond to serum or gas holes.



# What's next? Modified matrix study (melt)

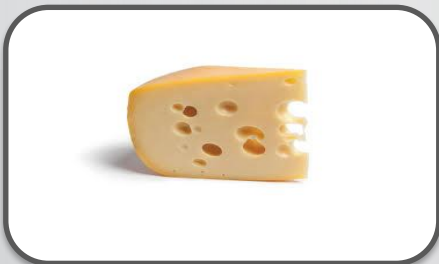
- **Aim:** Determine the effect that heating (melting) has on the cheddar cheese matrix by comparing long term effects of consumption of melted and solid cheddar cheese.
- **Null hypothesis** – The cheese matrix **form** (solid and melted) has no negative impact on markers of metabolic health

**Inclusion Criteria:** 50 – 69 years, with BMI of 25 or over

**Intervention:** 42g fat in 3 matrices (cheese, butter or reduced fat cheese) for 6w

**Outcomes:** Markers of heart health (LDL-C, HDL-C, key inflammatory cytokines)

**A**



**B**



**C**



# Summary

- Cardiometabolic health and dairy – overall neutral or beneficial associations
- Food matrix – can exhibit different actions than the corresponding actions of individual food components
- Dairy matrix – need to look at individual dairy products – not all the same
- Dairy fat within cheese matrix – potential beneficial effects on blood lipid profiles
- Future research: How is cheese consumed? – important to look processing effects of cheese structure i.e melted





# Acknowledgements

## **Cheese study team:**

Prof. Eileen Gibney (UCD)

Dr. Emma Feeney (UCD)

Ms. Nupur Bhargava (UCD)

Ms. Simone Dunne (UCD)

Ms. Shuhua Yang (UCD)

Ms. Michelle O'Rourke (UCD)

## **Past team members:**

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Ms. Zita Hamilton (UCD)

Ms. Rebecca Barron (UCD)

Ms. Vicky Dible (UCD)

Ms. Aisling Daly (UCD)

## **FHI team:**

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Prof. Dolores O'Riordan (UCD)

Dr. Diarmuid Sheehan (Teagasc)

Mr. Adam Cogan (Teagasc)

Mr. Mick O'Sullivan (UCD)

Ms. Michelle O'Rourke (UCD)

Plus, many more....