FOOD MATRIX EFFECTS: IS IT TIME TO RE-THINK HOW WE EVALUATE THE HEALTH EFFECTS OF FOODS?

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What is the food matrix?
Nutrient-based nutrition system

Assumes nutrient additivity and exclusivity
What is the food matrix?

What is a matrix?

...a substance in which other things are fixed, buried, etc...
Can the food matrix affect nutrient bioavailability?
Effect of food matrix of wheat on glycaemic response

Jenkins et al. (1998)
Effect of almond particle size on lipid bio-accessibility \emph{in vitro}

Grundy et al. (2015a)
Effect of mastication of almonds on parenchyma cell damage and hence lipid bioavailability

Grundy et al. (2015b)
Acute effect of 50g fat on plasma TAG in healthy men

Health effects of a food cannot be determined simply on the basis of the individual nutrients
The dairy food matrix:
Some examples
Effect of 40 g fat/day for 8 weeks with (whipping cream) and without (butter oil) MFGM on plasma lipids

Rosqvist et al., 2015

Confocal laser scanning micrographs

Milk fat globules in emulsion from butter oil
Fat=red; MFGM=green

Milk fat globules from whipping cream
Fat=red; MFGM=green

Physical matrix effect
Effect of 40 g fat/day for 8 weeks with (whipping cream) and without (butter oil) MFGM on plasma lipids

Health effects of a food cannot be determined simply on the basis of the individual nutrients

Rosqvist et al., 2015

Physical matrix effect
Plasma lipids at baseline and after butter and cheese (both 40 g fat/d for 4wk)

Nestel et al., 2005

No Ca data
Changes in total and LDL-cholesterol after consumption of ~80 g/d fat (~36g/d SFA) as cheese or butter for 6 wk

Hjerpsted et al., 2011.

*** Cheese vs. butter (P<0.0001)  ††⁺/⁺ Butter vs. run-in (P<0.0005/0.05)

Ca
1192 mg cheese, 417 mg butter
No effect on faecal fat excretion
Dairy calcium intake modifies faecal fat, Ca and bile acid excretion

Lorenzen and Astrup (2011)

<table>
<thead>
<tr>
<th></th>
<th>High fat</th>
<th>Low fat</th>
<th>P for</th>
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<tbody>
<tr>
<td></td>
<td>Ca</td>
<td>Fat</td>
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<td>Faecal losses</td>
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<tr>
<td>Low Ca</td>
<td>6.6</td>
<td>5.5</td>
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<td>High Ca</td>
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<td>8.0</td>
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<td>Ca (mg/d)</td>
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<tr>
<td>Low Ca</td>
<td>549</td>
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<tr>
<td>High Ca</td>
<td>2477</td>
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<td>Bile acid (µmol/d)</td>
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<td>Low Ca</td>
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<tr>
<td>High Ca</td>
<td>393</td>
<td>346</td>
<td>NS</td>
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Faecal fat only explains about 30% of effect on cholesterol
Effect dairy Ca from cheese and milk on blood lipids in young men (~46g SFA/d)

Soerensen et al., 2014

No effect on HDL-C

Ca mg/10MJ
362 Control (Butter only dairy)
1143 Milk
1172 Cheese

Change in cholesterol (mmol/L)

Total cholesterol LDL cholesterol

* No effect on HDL-C
Meta-analysis of RCTs: cheese vs. butter on LDL-C (TC same)

De Goede et al., 2015

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Mean Difference (95% CI)</th>
<th>% Weight</th>
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<tbody>
<tr>
<td>Tholstrup</td>
<td>2004</td>
<td>-0.21 (-0.41, -0.01)</td>
<td>14.90</td>
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<tr>
<td>Biong</td>
<td>2004</td>
<td>-0.22 (-0.39, -0.05)</td>
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<tr>
<td>HJerpsted</td>
<td>2011</td>
<td>-0.21 (-0.31, -0.11)</td>
<td>62.04</td>
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<tr>
<td>Soerensen</td>
<td>2014</td>
<td>-0.38 (-0.80, 0.04)</td>
<td>3.31</td>
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</tbody>
</table>

Overall
(l-squared = 0.0%, p = 0.898)

-0.22 (-0.29, -0.14) 100.00

NOTE: Weights are from random effects analysis

Favours cheese
Δ mmol/L
Favours butter
Is the role of Ca in reduced fat absorption due to saponification with fatty acids?

Answer: probably, but chemical confirmation needed and Ca probably also with P involved in increased bile acid excretion

Thorning et al. 2016 (pigs)
Effect of reduced bile acid enterohepatic recycling on plasma cholesterol

Chemical matrix effect
Do certain components in the food matrix modify/compensate fat/SFA effects?
PP kinetics of TAG after high fat meal including casein, whey protein and enriched whey protein

Mariotti et al. (2015)
Milk proteins and blood lipids

Fekete et al., AJCN (2016)

Δ baseline (mmol/L)

TC  LDL-C  TAG

Whey protein  Ca-caseinate  Control

a, b different = P < 0.05

Association matrix effect
Conclusions

• Food matrix effects exist
• The matrix effect is probably mainly a combined function of nutrient composition and food structure
• May be physical, chemical or associative and maybe all?
• They mean that health effects of a food cannot be determined simply on the basis of the individual nutrients it contains.
• The food matrix can determine nutrient digestion and absorption, thereby also altering the overall nutritional properties of the food.
• Evidence to date suggests the dairy matrix may have unique benefits for bodyweight control, bone and cardiovascular health but more on these to follow.....
Thank you