Interactions between macronutrients

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POTENTIAL INTERACTIONS OF FOOD COMPONENTS ADDED TO ENHANCE THE DIET

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10 things to know about nutrient interactions

1. Increasing one nutrient by adding it to food is different than increasing that nutrient by eating more. The manner of increase my influence interactions between that nutrient and others.

2. Interactions can occur at many levels. Nutrients can interact in many systems.

3. Not all interactions are negative.

4. Not all interactions are known.

5. Interactions may be short or long term. Interactions seen in the short term may not occur over the long term. Interactions not seen over the short term may occur over the long term.

6. The extent of an interaction may depend on nutritional status.
10 things to know about nutrient interactions

7. Subgroups are important. Interactions may benefit one group and disadvantage another. Reluctance to fortify may benefit one group, but disadvantage another.

8. Food consumption patterns should assist in choice of fortification vehicles.

9. “Headline” nutrients are not the only ones that matter.

10. Potential interactions, effects on subgroups, nutritional status and food sources should be considered before fortifying and should be monitored as fortification continues.
Types of nutrient interactions

- Macronutrients with macronutrients
- Macronutrients with vitamins
- Macronutrients with minerals
- Vitamins with vitamins
- Minerals with minerals

- Protein - fat
- Protein - carbohydrate
- Fat - carbohydrate
Interactions can occur at many levels

- Absorption
- Transport
- Storage
- Utilization
- Excretion
- Appetite
Interactions can occur in many systems

Intestinal tract

- absorption
- motility / transit
- pH
- osmolality
- solubility
- viscosity
Starch-lipid interactions

Lipids (emulsifiers) are often added to starch containing foods to:

- reduce stickiness in pasta, mashed potato, sweets
- prolong shelf-life of bread
- modify rheological properties

Factors that influence solubility of lipid affect degree of complexes formed
Starch – lipid complexes

Structure of amylose-lipid complex.
From Blasek 2008, adapted from Buleon et al. (1998).
Effects of starch-lipid interactions

Adding lipids to starch affects:

- gelatinisation
- swelling
- viscosity
- retrogradation
- enzymic degradation/digestibility
## Englyst’s Nutritional Classification of Starch

<table>
<thead>
<tr>
<th>Type of Starch</th>
<th>Examples</th>
<th>Digestion in small intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapidly digestible starch (RDS)</td>
<td>Freshly cooked starchy foods</td>
<td>Rapid</td>
</tr>
<tr>
<td>Slowly digestible starch (SDS)</td>
<td>Most raw cereals, pasta</td>
<td>Slow but complete</td>
</tr>
<tr>
<td>Resistant Starch (RS)</td>
<td></td>
<td>Resistant</td>
</tr>
</tbody>
</table>

**Figure 6.4** Starch hydrolysis curves for seven foods, showing that starches from different sources or in different food forms are digested at variable rates.

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Source: Englyst, Kingman and Cummings, 1992

Englyst et al 1987
## Classification of Resistant Starch

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<th>Type of Starch</th>
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<tbody>
<tr>
<td>Physically inaccessible starch (RS1)</td>
<td>Partly milled grains, seeds, legumes</td>
<td>Resistant</td>
</tr>
<tr>
<td>Resistant starch granules (RS2)</td>
<td>Raw potato, banana, high amylose maize (corn)</td>
<td>Resistant</td>
</tr>
<tr>
<td>Retrograded amylose (RS3)</td>
<td>Cooked, cooled potato, bread, cornflakes</td>
<td>Resistant</td>
</tr>
</tbody>
</table>

*Englyst et al 1987*
Intrinsic factors that influence the extent of resistant starch

- source of starch
- amylose/amylopectin ratio
- size of granules
- anti-nutrients and enzyme inhibitors
- interactions with NSP
- interactions with protein
- interactions with fat
- food processing
% Amylose hydrolysed to free glucose

Time (hours)

- Amylose
- Amylose + Lauric acid

% Effect of fatty acids on starch digestion

Crowe et al 2000
Effects of varying fatty acids type and concentration on formation of starch–lipid complexes

Tang and Copeland 2005
Factors affecting extent of starch-fat interactions

- type of starch – amylose vs amylopectin
- amount and type of fat –
  - triglyceride vs fatty acid
  - type of fatty acid
  - limited combining for certain types and not others
- time of interaction
  - when food is prepared/cooked
  - when food is eaten
Physiological impact of fat-carbohydrate interactions

- Impact through effects on Resistant Starch formation
  - Faecal bulking - constipation
  - Short chain fatty acid formation – colon cancer
- Impact on glycaemic response
What Is The GI?

The GI is defined as the incremental area under the blood glucose response curve of a 50g carbohydrate portion of a test food as a percent of the response to the same amount of carbohydrate from a standard food taken by the same subject.

*FAO/WHO Expert Consultation: Carbohydrates in Human Nutrition 1998*
Fat and protein on glycaemic response

FIG 1. Blood glucose increments after test meals (x ± SEM). ●● potato alone, ■■ potato with protein, △--△ potato with protein and fat; ○○ spaghetti alone, □□ spaghetti with protein, △--△ spaghetti with protein and fat.

Gulliford et al 1989
Effect of fat on the glycaemic response

Mean (SEM) blood glucose concentrations of 12 normal subjects after consuming 100g white bread alone (●) or 100g white bread plus 5g (○), 10g (▲), 20g (△) or 40g (♦) fat from non-hydrogenated margarine.

Owen and Wolever 2003
Mean changes in plasma glucose in 11 healthy subjects after consumption of ◇, Glucose; ◆, mashed potato; ▲, mashed potato with oil; □, mashed potato with chicken breast; ■, mashed potato with salad; ×, mashed potato with oil, chicken breast and salad; +, mashed potato with oil, chicken breast, salad and rye bread.

Hatonen et al 2011
GI value for test meals and toppings

This study has shown that addition of foodstuffs to staples had a consistent lowering effect on the GI value of the meal.

These findings emphasise the importance of investigating the GI of composite meals.

Henry et al 2006
Implications of fat-starch interactions

• Adding fat improves glycaemic response

  • Should we add fat to food to achieve this?

  • Must weigh benefits and disadvantages of extra fat vs lower glycaemic response
    • + lower glycaemic response
    • - added fat
    • - increased energy

• Varying fat content means GI of food is not constant

  • Can we have values for GI in food composition databases?
Glycaemic index in epidemiology


Glycaemic index in epidemiology – meta analyses


Glycaemic index in epidemiology


- Barrett JS, Gibson PR. *Development and validation of a comprehensive semi-quantitative food frequency questionnaire that includes FODMAP intake and glycemic index*. J Am Diet Assoc. 2010 110:1469-76.

Methodological Challenges in the Application of the Glycemic Index in Epidemiological Studies Using Data from the European Prospective Investigation into Cancer and Nutrition.


J Nutr 139:568-75. 2009
Limitations to assigning appropriate GI values include the restricted number of items in the Foster-Powell table, the inclusion of mainly American or Australian food items, lack of values for mixed dishes, and the lack of information on differences in variety, degree of ripeness, composition (e.g. more or less fat), cooking methods, and product formulations of the same brand.

It is of great importance for future research on GI and GL to generate more European-specific GI values, such as bread, potatoes, cakes, and breakfast cereals.....

van Bakel MM et al J Nutr 139:568-75. 2009
Despite these limitations, the ranking of participants to their GL value seems acceptable with the existing measurements of dietary intake, but the ranking of participants according to GI should be used with caution.

van Bakel MM et al J Nutr 139:568-75. 2009