Food targets for appetite control

Satiety and appetite control claims: Getting it right for consumers

27th November, Dr. Monica Mars
Foods differ in their satiating capacity

- Classic ranking:
  - Protein
  - CHO
  - Fat

- Type of:
  - Carbohydrates
  - Protein
  - Fiber
Physical chemical properties affect satiety

- E.g. viscous fibres reduce food intake more often
  - Physical-chemical properties?
  - Reaction to low PH?
  - Water holding capacity?
  - Hydration of the fibre?
  - Matrix of the fibre?
  - Nutrient binding?
  - Fermentation products?
Peripheral signals

Pre-absorptive:
- Stomach (fullness, emptying)
- Release of gastro-intestinal hormones (nutrient sensing)
- GI function (motility, ileal break)

Post-absorptive:
- Glucose homeostasis (?)
- Other metabolites

Colon: fermentation products?

Delzenne et al., 2010
But how to quantify the effects on these mechanisms?

**Biomarker** of the proposed mechanism

- A direct or indirect biological measure
- Definition of biomarker in “epidemiology”
- But should be valid (causal), sensitive, precise and **specific**

Satiety:
- Hunger
- Fullness
- Desire to eat
- Prospective consumption
Hundreds of processes are affected after food has been ingested
Review of the literature (de Graaf et al., AJCN 2004)

**TABLE 1**
Evaluation of potential biomarkers of satiety according to 6 criteria

<table>
<thead>
<tr>
<th>Candidate biomarkers</th>
<th>Causal factor in appetite, or indirect measure</th>
<th>Feasibility of measurement</th>
<th>Validity (plausible mechanism)</th>
<th>Sensitivity or specificity (strength of relation with appetite)</th>
<th>Reproducibility (consistency in findings)</th>
<th>Effect of food components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satiation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brain image sensory</td>
<td>Indirect</td>
<td>−</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Specific satiety</td>
<td>Indirect</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
</tr>
<tr>
<td>Stomach fullness</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>CCK</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>GLP-1</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
</tr>
<tr>
<td>Bombesin</td>
<td>Unknown</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Somatostatin</td>
<td>Unknown</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Satiety</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Brain imaging of satiety</td>
<td>Indirect</td>
<td>−</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Diet-induced thermogenesis</td>
<td>Indirect</td>
<td>−</td>
<td>+/−</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Body temperature</td>
<td>Indirect</td>
<td>+</td>
<td>+/−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Absolute glucose</td>
<td>Indirect</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
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<tr>
<td>Glucose decreases</td>
<td>Causal</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
<td>+/−</td>
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<tr>
<td>Insulin</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>+</td>
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<tr>
<td>Leptin, short-term</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>−</td>
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<td>−</td>
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<tr>
<td>Leptin, negative energy balance</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
<td>+/−</td>
</tr>
<tr>
<td>GIP</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
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<tr>
<td>Ghrelin</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>−</td>
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<tr>
<td>PYY</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
<td>+/−</td>
<td>+/−</td>
</tr>
<tr>
<td>Enterostatin</td>
<td>Causal</td>
<td>+</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

1 CCK, cholecystokinin; GLP-1, glucagon-like peptide 1; GIP, glucose-dependent insulninotropic polypeptide; PYY, peptide YY.
Almost all markers studied are “feasible”, except brain imaging and DIT.

Most all markers are causally involved in appetite (validity).

Specificity and sensitivity is debatable.
Reproducibility not established.

Not sufficient studies performed to give clear conclusions about relationships.
Peripheral signals

Pre-absorptive:
- Stomach (fullness, emptying)
- Release of gastro-intestinal hormones (nutrient sensing)
- GI function (motility, ileal break)

Post-absorptive:
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Colon: fermentation products?

Delzenne et al., 2010
Biomarkers used for GI function

Direct measurements
- Ultrasonography
- MRI
- Scintigraphy (golden standard for diagnoses)

Indirect measurements -> tracers
- Paracetamol in serum
  liquid phase
- Isotopes in expired CO$_2$ (eg. octanoate C$^{13}$)
  Liquid/solid phase

Delzenne et al., 2010
Release of GI peptides

- Produced by entero-endocrine cells
- “Nutrient sensing”

- Most studied and causal:
  - Ghrelin, CCK, GLP-1, PYY

- Complete overview article Delzenne 2010
Trend in publications on GI peptides

- Search: Satiety AND (Ghrelin OR GLP-1 OR CCK OR PYY)
Use of satiety peptides in assessing the satiating capacity of foods

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ABSTRACT

Foods differ in their satiating capacity. Satiety peptides may help to provide evidence for biological mechanisms behind these differences. The aim of this paper was to discuss the physiological relevance of three individual appetite peptides, i.e. CCK, GLP-1 and PYY, in assessing the satiating capacity of foods. A literature research was conducted on CCK, GLP-1, PYY and satiety; effective exogenous infusion studies and endogenous production studies, i.e. changes induced by foods, were identified. The relative changes in blood concentrations in these studies were compared in order to assess an indication of the physiological relevance of the peptides. Relative changes in the two types of studies investigating CCK overlapped, i.e. increases in serum
Physiological relevance of biomarkers

- Aim: to assess insight in the effective blood response of individual appetite peptides in assessing the satiating capacity of a food.

- Compare blood responses of:
  - Effective dosages of intravenous infusion of the peptide
  - Different foods/meals
Methods

Original articles between 2003 and 2009
Healthy human volunteers
CCK, GLP-1 and PYY

- Exogenous (intravenous infusion):
  - Effective dosages on appetite or food intake
  - Peak level compared to baseline level

- Endogenous (food ingestion):
  - Fixed test meal paradigm
  - Test meal should be between 1-4 MJ
  - Peak level compared to baseline level
Data extraction: example

- Ratio between baseline levels and peak-level
- Numbers from text or measured with pdf-measurement tool
- For example $1.56/0.21=7.4$: 7.4 fold increase
Satiety hormones physiological relevant?

- **CCK**: Increase >3 fold
- **GLP-1**: Increases >3.5 fold
- **PYY**: Increases > 3 fold

Mars et al., 2012
Conclusion

- Clear causal effect on appetite for all three hormones
- GLP-1 and PYY show relatively small responses to food
- CCK can show similar responses to food than effective infusions

- Effects on GLP-1 and PYY can not be interpreted by itself
- CCK however, may have an individual contribution
GI peptides

- Circulating peptides can be measured in serum
- Responses within individuals
- Reference food is needed
- In humans: no access to portal blood
- Fast degradation of peptides
- Low concentrations, small differences (sensitivity)
Glucose homeostasis - insulin

- Glucose level and circulating insulin
- Higher concentrations
- Reference values exist
- Relative simple biochemical assessment
- Glucose in finger pricks

- Causality/validity with satiety still discussed (dynamics, transient declines?)
Conclusions – key messages

- Changing properties of food may alter physiological processes involved in the satiety cascade

- Markers of physiological processes can not be used individually to prove the satiating capacity of foods

- An effect of appetite related measures, which is supported by (a combination of) biological measurements may be used to substantiate a claim on the satiating capacity of foods
Thank you for listening!

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