Dairy matrices: effect of processing and composition on microstructure and nutritional properties

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Outline

- Context
  - Effect of food structure on nutritional value
  - Diversity of dairy products structural organization

- Aim of the research project

- Two major dairy components studied:
  - Proteins and lipids and possible effect of kinetics of their digestion and absorption

- Conclusion/ perspective
Context- food as a black box

Nutritionist and gut physiologist study foods based on their composition

Structure is usually not considered

Digestion is a complex process

Definitions
Bioaccessibility
- Release of the nutrient from the food matrix into the GI tract

Bioavailability
- Portion of nutrient that is absorbed and actually reach the systemic circulation
Food matrix impact on macronutrients nutritional properties

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ABSTRACT

The food industry is aware of the consumer’s desire to purchase delicious, convenient and nutritious foods. Rapid development of functional foods has induced the food industry to evaluate and revise the composition of their processed foods as well as their processing conditions and methods to improve nutritional and health effects. The addition of new bioactive compounds to a food requires that the
Figure 1: Impact of processing and formulation steps to improve/control macronutrients nutritional properties
Kinetics of nutrient release

- Well-known examples:
  - Fiber reduces glycemia
    - (rate of glucose appearance in serum);
    - Increase in viscosity;
    - Modification of enzymatic activity/ access to substrate, etc.
  - Protein release vs glycemia and satiety;
  - Lipemia (rate of lipid appearance in serum)
    - Depends on amount and nature of dietary triglycerides and the presence of other nutrients
Diversity of dairy products structural organization

Aguilera, 2005
Specific digestion behaviour of dairy proteins

Total leucine rate of appearance in serum after ingestion

Boirie et al 1997
Aim:

- Establish the link between physical characteristics of various dairy matrices and protein and lipid bioaccessibility and bioavailability.
Study of protein digestion in two milks with different heat treatment

Laure Rinaldi
Digestion model – liquid matrix

**Dynamic mechanical actions**

- **Mixing**
  - Orbital stirring

**Digestion steps (37 °C)**

1. 9g of dairy product
2. 6mL saliva - pH 6.8 - 20s
3. 12mL (twice 6mL) gastric solution - pH 1.3 - 30min
4. 12mL duodenal soln
   - 6mL bile
   - 2mL NaHCO₃
   - pH 8.2 - 60min

**Digestion products treatment**

- Homogenization (9500rpm, 20s)
- To stop enzymatic activity

*Adapted from Versantvoort et al. 2005*
Commercial milks:
Pasteurised and traited by Ultra High Temperature

Dairy matrix studied by *Lacroix et al.*, 2008:

different protein digestion kinetics
Are caseins totally digested?

2 repns, 
10⁻⁶g proteins/well

**Gastric digestion (SDS-PAGE) results**

- Undig.
- Past.
- 4min
- UHT

**β-lg**

**cns**
Gastric digestion (SDS-PAGE) results

**UHT**

**Pasteurised**

2 repns, 4.10⁻⁵g proteins/well
Undig.: 10⁻⁶g

Undig. Gast.: 2min 15min 30min
Gastro-intestinal digestion model *in vitro*:
able to distinguish milk digestion kinetics differences upon different industrial process
Amino acids bioaccessibility results

• AA unbioaccessible in stomach
• Free AA quickly from the beginning
  • 2-3 times more free AA for UHT milk than pasteurised
Peptide bioaccessibility  materials & methods

Products of digestion from pasteurised vs sterilised milks

Study of peptides with LC/MS
  • Complex chromatograms
  • Different appearance kinetics of peptides upon:
    milk
    selected peptide

Poster 14
Digestions of milks with different heat treatment

**In vitro** model:
- different digestion kinetics upon UHT vs pasteurised milk
- tendency agreed with *in vivo* study

**Future**

Study of semi-liquid matrix:
- commercial yogurts and yogurts with controlled process
- study *in vivo*, rats
Impact of calcium on physical disintegration and lipolysis of cheddar cheese during *in-vitro* digestion

Erik Ayala Bribiesca
Context

- **Importance of the food matrix**
  - Modulate nutrient release

- **Cheddar cheese: model dairy matrix**
  - Well-known solid matrix
  - Commercial and industrial importance
  - Standardized production parameters
  - Source of calcium and lipids
Cheese as a model matrix
- Interaction between calcium and proteins
  - Structuring of the paracasein gel

Cheese under digestive conditions
- Interactions between calcium and lipids
  - Pancreatic lipase efficiency
  - Calcium soap production
  - Long chain fatty acids excretion

1Metzger and Mistry, 1994; 1995
2Hu et al., 2010
3Denke et al., 1993
Hypothesis

- Calcium enrichment of the cheddar cheese matrix increases its resistance to physical disintegration during *in-vitro* digestion.

- Calcium content in cheddar cheese has an impact on lipolysis during *in-vitro* digestion.
Experimental

- **Cheddar cheese production**
  - calcium enrichment
    - CaCl$_2$ added during the salting process

- **In-vitro$^1$ digestion of cheeses**
  - in conical tubes
  - head-over-heels agitation with glass beads

- **Analysis of chymes**
  - physical disintegration of cheeses
    - pass through metal mesh (1.5 mm x 1.5 mm)
  - lipolysis rate
    - free fatty acids

$^1$adapted from Versanvoort et al. 2004
Results and discussion

Physical disintegration of calcium-enriched cheddar cheeses during *in-vitro* digestion

Disintegration (%) vs. Digestion progress (minutes)

- **Gastric phase**
- **Duodenal phase**

- **0 mg Ca/g curds**
- **4 mg Ca/g curds**
- **12 mg Ca/g curds**
Results and discussion

Lipolysis of calcium-enriched cheddar cheeses during *in-vitro* digestion

![Graph showing lipolysis rate over digestion progress (minutes)].

- **Lipolysis rate (%)**
- **Digestion progress (minutes)**: 90, 120, 150, 180, 210, 240, 270, 300
- **Duodenal phase**
- **mg Ca / g curds**

Legend:
- 0
- 4
- 12
Conclusion

- Effect of calcium supplement
  - Slower disintegration of the matrix
  - Faster lipolysis of accessible fat

- Calcium enriched cheeses had higher lipolysis rates although they presented slower disintegration rates.
Perspectives

Analyses in process
- Fatty acid profiles (gas chromatography)
  - Fatty acids present as calcium soaps
- Cheese matrices characterization
  - Texture profile analysis
  - Colloidal calcium

Future works
- Cheese with different milk-fat fractions

Potential reach
- Modulation of lipid bioaccessibility
  - Possible impact on metabolic responses