Functional starch: A better use of starch in foods

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• Summary
  o Food chemistry, carbohydrates/starch chemistry
  o A specialist in modification techniques of starch
    • Chemical, physical, and enzymatic method
    • For specific application in food system and industrial purposes
  o A strong research background in fundamental aspect of carbohydrates polymers/starches and their derivatives

• Education
  Ph.D., School of Food Science, University of Idaho, Moscow, Idaho, US. Jan 2013
  M.S., 서울대학교 식품생명공학과 (Enzyme technology) Feb 2008
  B.S., 동국대학교 식품공학과 Feb 2006
Current affiliation
Department of Microbial and Molecular Systems

Centre for Food and Microbial Technology

Laboratory of Food Chemistry and Biochemistry
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Laboratory of Food Technology

Laboratory of Food Microbiology

Laboratory of Malting and Brewing Sciences
Lab LFoRCe
Mission

• To generate basic insights in
  o Structure and properties of cereal constituents
    • Starch
    • Non-starch polysaccharides
    • Storage proteins
    • Enzymes
    • Lipid

• To improve processing, final products and/or hearth related functionality
Starch?

• Energy storage form in plants
• The most important carbohydrate in the human diet
• Abundant source of functional biopolymers
  o Thickeners and stabilizers in food and non-food products
  o Biodegradable components in numerous chemical applications (e.g., plastics, detergents, glues etc.)
Starch application
EU - 2013

Total Market: 9 million tones

Confectionary and drink (32%)
Processed foods (29%)
Corrugating and paper making (29%)
Pharma & Chemicals (5%)

European starch industry association (aAf)
Extraction of starch from plants

wheat

Kernel (100%)

Milling

Flour (76 - 78%)

Isolation

Starch (58 - 60%)

whole wheat flour

Bran
Starch granules
Scanning electron microscopy

corn (48%)
wheat (39%)
potato (13%)
rice
banana
pea
Starch in Foods
Food thickener
Starch in Foods

Phase transition

95°C $\text{H}_2\text{O}$  $\rightarrow$ 50°C $\text{H}_2\text{O}$  $\rightarrow$ 5°C

Gelatinization  Retrogradation  Gelation

Graph showing temperature and viscosity changes over time.
To obtain functional starch,

- Need additional process (modification) to enhance functionality of starch using
  - Chemicals
  - Enzymes
  - Physical treatments
  - Dual/multiple processes

- Viscosity of 7% (w/v) native starch and cross-linked starch in 92.5% (w/w) DMSO-water solution (Hong et al., 2015)
Functional food starch

- 80% of starch in markets is modified!
  - Fat Replacer/Fat Mimetic
    - Low-fat butter spread/margarine
    - Low fat mayonnaise
    - Low fat milk type products
    - Low-fat ice cream
  - Texture Improvers
    - Improve bread texture
    - Crispness of crackers and biscuits
    - Viscosity breakdown resistant for can foods
    - Desired chewiness for extruded products
  - Functional fiber
    - Slow digestible cookies
    - Resistant starch muffin
  - Encapsulation of flavor/oil

Abbas et al. 2010
Functional food starch
Prospects

- Chemical levels ↓
- Effect of starch modification ↑
- Precise control of the modification process
- Advanced techniques to produce functional starches
- Novel functionality of food starches
- “Clean” labeled food starch

Better understanding of starch structure and reaction patterns
Starch structure
Microscopic view

- Scanning electron (SEM)
- Powder (X1)
- Confocal laser scanning (CLSM)
- Glass slide
  *Fluorescence* probed starch granule
- Wax
- Growth ring (X10^-6)
- Cavity
- Channel

Starch granule (X10^-5)
Starch structure
Amylose and Amylopectin

Amylose

Amylopectin

Cluster

Plant pathology online
Starch structure
From granules to molecules

Granular level

Molecular level

Jenkins & Donald, 1995
Proposed model for starch molecules organization
Based on reactivities of starch chains

Cluster model (traditional model)

Backbone structure model (alternative model)

Hong & Huber (2015)
Overall research goal & approach

• Model reaction system
  o Fluorescent probed starch derivatives
Conclusions

• Starch granular architecture impacts reactivities of starch chains molecules.

• Granular/molecular reaction patterns impact physical properties of modified starches.

• By controlling reaction parameters,
  o “Design of reaction pattern”
  o A minimal level of reagent addition

• Starch model reaction approach: provides insight beyond current understanding of starch structure.
Carbohydrates and Health

“Tell me what you eat, and I will tell what you are.”
- Jean Anthelme Brillat-Savarin

The relationship between protein:carbohydrate dietary intake vs. lifespan in Mice (Simpson et al., 2014)

The quality of carbohydrates is important!