Ingredients & Functional Foods

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'Microbiome-based Foods for Health and Sustainability'

23 February 2016
The gut microbiome and health

• The **composition and activity of the gut microbiome** are linked to health and well-being, etiology and progression of disease.

• The **interaction of the gut microbiota with the host** is not limited to the **intestinal tract** but also reaches **extra-intestinal sites** thereby affecting systemic immunity, lipid and glucose metabolism, adipose tissue development, ao.

• **Dietary habits** is one of the main factors contributing to the composition and activities of the gut microbiota.

<table>
<thead>
<tr>
<th>Dysbiosis-Associated Diseases or Conditions</th>
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<tbody>
<tr>
<td>Obesity</td>
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<tr>
<td>Metabolic syndrome</td>
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<td>Nonalcoholic steatohepatitis</td>
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<td>Inflammatory bowel diseases (Crohn’s disease, ulcerative colitis, pouchitis)</td>
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<td>Irritable bowel syndrome, functional bowel disorders</td>
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<td>Atherosclerosis</td>
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<td>Type 1 diabetes</td>
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<td>Autism</td>
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<td>Allergy</td>
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<td>Asthma</td>
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<td>Celiac disease</td>
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See reviews by Bäckhed et al. (2005), Honda and Littman (2012), Ringel and Carroll (2009), and Sartor (2008, 2010).
Obesity and the gut microbiome

Causal relationship between the gut microbiome and obesity
presence of microbes changes the impact of diet

Bächked et al. PNAS 2004

Ridaura et al. Science 2013
Walker et al. Science 2013
Suggested that obese individuals may have a lower Bacteroidetes/Firmicutes ratio than lean individuals and this can be modulated by diet.
Dietary Impact on Microbial Richness in Obesity

Dietary intervention can partially correct for a loss of richness. Improved gene richness correlates with improvement in systemic metabolic status.
SATIN EU Project

• Multi-disciplinary research consortium across Europe
• Large Scale Integrated Project (FP7-KBBE-2011.2.3.-04)
• “Satiety control through food structures made by novel processing”
• 5-Year duration (until 2016)
• EU Contribution: 6 million euro
• 18 Partners in 8 countries

The Satiety Innovation investigates which foods accelerate satiation, suppress hunger, extend satiety within your meals and reduce appetite. By using latest processing methods the project aims to develop food products than can help with energy intake, metabolic disease and weight control.
Dietary supplementation with type 3 resistant starch in overweight human volunteers

19 overweight males and females (BMI 27-35 kg/m²)

**Faecal samples** were collected at two time points during each dietary stage and sequenced by Illumina Miseq.

**High level of interpersonal variation**

Significant **reduction in fasting blood glucose levels** after RS consumption in comparison to control diet.

~61% of interpersonal variation in comparison to the ~3% explained by diet

Non-multidimensional scaling analysis clearly reveals that samples grouped much more strongly by subject than diet

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Fig. NMDS clustering analysis generated using Phyloseq. Each colour represents an individual (A) diet or (B) subject.
Resistant starch selectively enriches a distinct group of diet-responsive bacteria

Significant increase of the *Ruminococcus* genus largely attributable to the primary starch degrader *R. bromii* (~2.6x increase in 80% of subjects)

Opposing responses from species within the same genus: *R. bromii* (OTU 1972) significantly enriched by RS3, whilst an unknown *Ruminococcus sp.* (OTU 61) experienced a reduction.
Wheat Bran Extract rich in Arabinoxylan Oligosaccharides (AXOS)

**AXOS**
- Hydrolysis products from arabinoxylans, the major fiber source in wheat bran
- Backbone of xylose residues and substituted with arabinose
- Ferulic acid can be covalently linked to arabinose

**Insoluble arabinoxylans**

**Soluble AXOS**

- Xylose
- Arabinose
- Ferulic acid
- Xylanase
Health Benefits of Wheat Bran Extract

- Selective and significant **increase in levels of bifidobacteria** in 4 separate human trials, clearly indicative of a prebiotic effect (Cloetens et al., 2010, Maki et al., 2012, François et al., 2012/2014).

- Prebiotic effects are observed at **daily dose of 5g AXOS**.

- Significant **increase in levels of colonic short chain fatty acids** and **decreased colonic pH** in human trials.

- Significantly decrease in urinary p-cresol levels in human trials, indicative of a **decrease in proteolytic fermentation**.

- **Well tolerated** in adults and children.

- Significant **increase in plasma ferulic acid levels**, indicative for its anti-oxidative potential.

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Ferulic acid (FA) levels (plasma)
Acute meal test responses at the beginning and end of each treatment period (volunteers ≥ 50 yrs)
Elucidate the role of the human microbiome and related features (lifestyle, host genetics) in nutrient metabolism and energy expenditure contributing to or predicting diet (obesity and metabolic syndrome) and brain-related disorders

Provide proof-of-concept of the disease risk-reduction potential of dietary interventions with new ingredients/foods
In vivo fermentation of various grains fractions

HEALTHGRAIN

SCFA in portal vein of rats (μmol/L)

Wheat Tiger

Knud Erik Bach Knudsen & Anja Serena, University of Aarhuis
Heart health benefits: potential mechanisms

Key nutrients in aleurone

Antioxidant related
✓ Tocopherols: α-tocopherol, γ-tocopherol
✓ Ferulic Acid (FA)

Methyl donor related
✓ Folate
✓ Choline
✓ Betaine

Antioxidative potential
↓ Oxidative damage
↓ Risk CHD, cancer and diabetes
+

Methyl donor micronutrients
↓ Homocysteine (tHcy)
↓ Risk stroke and CHD

Consumption of Wheat Aleurone-Rich Foods Increases Fasting Plasma Betaine and Modestly Decreases Fasting Homocysteine and LDL-Cholesterol in Adults

Evaluation of the effect of wheat aleurone-rich foods on markers of antioxidant status, inflammation and endothelial function in apparently healthy men and women


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(Received 11 April 2011 – Revised 23 November 2011 – Accepted 28 November 2011)
Conclusion

• Changes in gut microbiome linked to disease phenotypes
• Modulation of the gut microbiome by dietary strategies
• Fiber ingredients: different composition, several types of fibers, presence of bioactives leading to different physiological functions
• Potential for personalized dietary strategies