

Dietary fibre degradation, microbiota composition and gene expression in the colon

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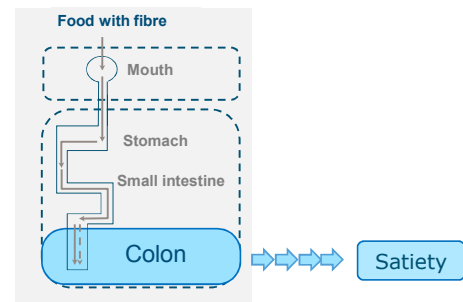
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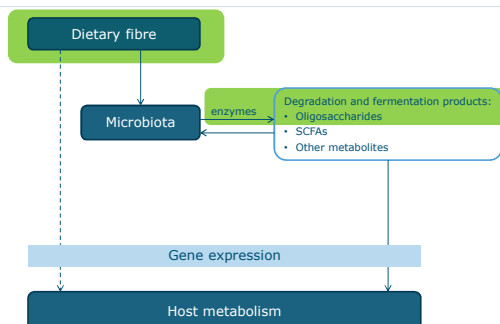
Dietary fibre in gastrointestinal system



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Interactions in the colon



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Experimental design

Growing male Landrace pigs

- Catheter
- Cannula in proximal colon



2 dietary treatments, 2 x 2 crossover design

Digestible starch (DS) and resistant starch (RS) diet, both for 14 days

Samples taken during the study

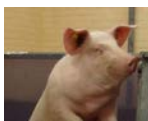
- Colonic luminal content and faeces
- Colon biopsies
- Plasma

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Diet composition

Ingredient	DS	RS
Digestible starch	35.0	0.0
Resistant starch	0.0	34.3
Wheat	20.0	20.2
Beet pulp (sugar < 100 g/kg)	5.0	5.1
Barley	15.0	15.2
Other ingredients	24.8	25.1
TiO ₂	0.2	0.2
Total	100.0	100.0



Dietary fibres

- Resistant starch
- Arabinoxylan
- Cellulose
- β-glucan
- Pectin

NSP*

Constituent monosaccharides

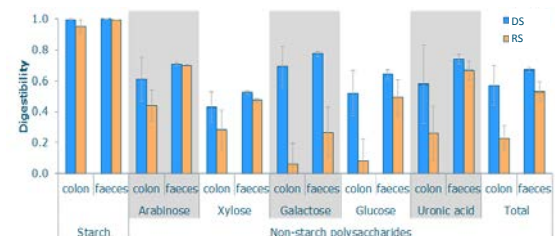
- Glucose
- Arabinose
- Xylose
- Galactose
- Uronic acid

*NSP: Non-Starch Polysaccharides

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Digestibility of starch and NSP in the colon of pigs

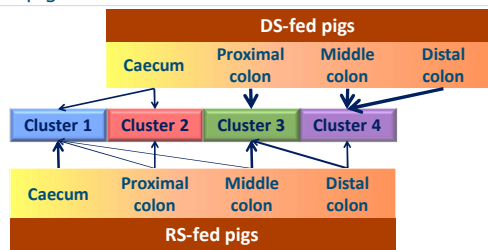


- Resistant starch delayed the digestion of NSP in the colon.
- Results were confirmed by enzyme activity profile in the digesta of pigs in another study.

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Fermentation profile in the colon of DS-fed and RS-fed pigs



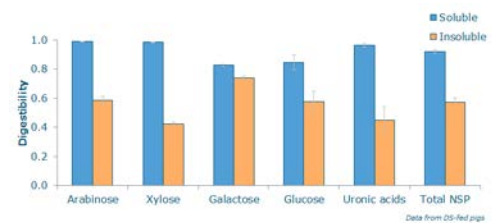
Fermentation profile in a certain part of the colon of RS-fed pigs resembled that in a more proximal part of the colon of DS-fed pigs.

Jonathan, M. C., D. Haenen, et al. (2013). "Influence of a diet rich in resistant starch on the degradation of non-starch polysaccharides in the large intestine of pigs." *Carbohydrate Polymers* 99: 232-239.

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Total tract digestibility of soluble and insoluble NSP



Soluble NSP are digested more than insoluble NSP.

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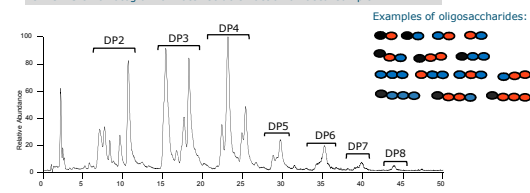
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Oligosaccharide formation in the colon Another dietary fibre: Alginate

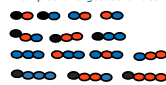
Dietary fibre sources in the experimental diet:

- Sodium alginate
- Soybean meal
- Wheat and wheat middlings

UPLC-MS chromatogram of water-soluble fraction of faecal sample



Examples of oligosaccharides:



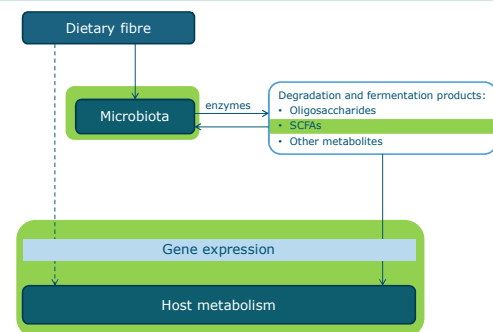
Oligosaccharides can be present in the colon as degradation products of dietary fibres.

Jonathan, M. C., G. Bosch, et al. (2013). "Separation and identification of individual alginate oligosaccharides in the feces of alginate-fed pigs." *Journal of Agricultural and Food Chemistry* 61(3): 553-560.

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Interactions in the colon



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Microbial groups increased in relative abundance

Phylum	Class	Genus	Change RS vs DS diet
Bacteroidetes	Bacteroidetes	<i>Prevotella melaninogenica</i> et rel.	↑
		Uncultured <i>Prevotella</i>	↑
Firmicutes	Bacilli	<i>Enterococcus</i> et rel.	↑
	<i>Clostridium</i> cluster IV	<i>Faecalibacterium prausnitzii</i> et rel.	↑
	<i>Clostridium</i> cluster IX	<i>Dialister</i> et rel.	↑
		<i>Megasphaera elsdenii</i> et rel.	↑
		<i>Mitsuokella multacidia</i> et rel.	↑
	<i>Clostridium</i> cluster XVIII	<i>Clostridium ramosum</i> et rel.	↑
Butyrate			Organic acids

Increase in healthy gut-associated microbial groups after RS consumption.

Haenen, D., C. Souza da Silva, J. Zhang et al. (2013). "Resistant Starch Induces Catabolic but Suppresses Immune and Cell Division Pathways, and Changes the Microbiome in Proximal Colon of Male Pigs". Accepted for publication in the *Journal of Nutrition*.

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Microbial groups decreased in relative abundance

Phylum	Class	Genus	Change RS vs DS diet
Proteobacteria	Alphaproteobacteria	Sphingomonas et rel.	↓
	Betaproteobacteria	Uncultured Betaproteobacteria	↓
	Gammaproteobacteria	Actinobacillus indolicus et rel.	↓
		Aeromonas	↓
		Alishewanell et rel.	↓
		Halomonas et rel.	↓
		Pasteurella et rel.	↓
		Pseudomonas et rel.	↓
		Psychrobacter et rel.	↓
		Ruminobacter amylophilus et rel.	↓
		Vibrio et rel.	↓
		Xanthomonas et rel.	↓
Spirochaetes	Spirochaetes	Leptospira	↓

Decrease in potentially pathogenic microbial groups after RS consumption.

Haenen, D., C. Souza da Silva, J. Zhang et al. (2013). "Resistant Starch Induces Catabolic but Suppresses Immune and Cell Division Pathways, and Changes the Microbiome in Proximal Colon of Male Pigs". Accepted for publication in the *Journal of Nutrition*.

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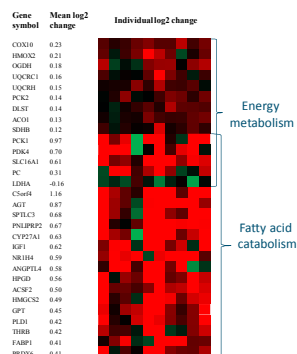
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Induction in gene expression

- Expression > 17,000 genes determined
- Expression 459 genes significantly ($P < 0.01$) increased with RS

Increased expression of genes involved in:

- fatty acid catabolism
- energy metabolism
- cell-cell contact after RS consumption.



Haenen, D., C. Souza da Silva, J. Zhang et al. (2013). "Resistant Starch Induces Catabolic but Suppresses Immune and Cell Division Pathways, and Changes the Microbiome in Proximal Colon of Male Pigs". Accepted for publication in the *Journal of Nutrition*.

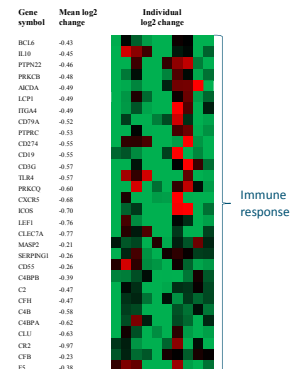


Reduction in gene expression

- Expression 289 genes significantly ($P < 0.01$) decreased with RS

Decreased expression of genes involved in:

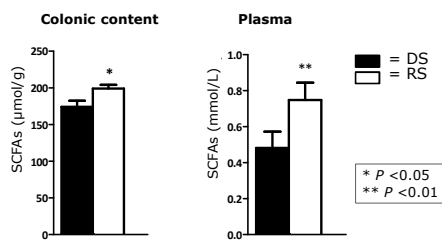
- adaptive immune response
- innate immune response
- transcription and translation after RS consumption.



Haenen, D., C. Souza da Silva, J. Zhang et al. (2013). "Resistant Starch Induces Catabolic but Suppresses Immune and Cell Division Pathways, and Changes the Microbiome in Proximal Colon of Male Pigs". Accepted for publication in the *Journal of Nutrition*.



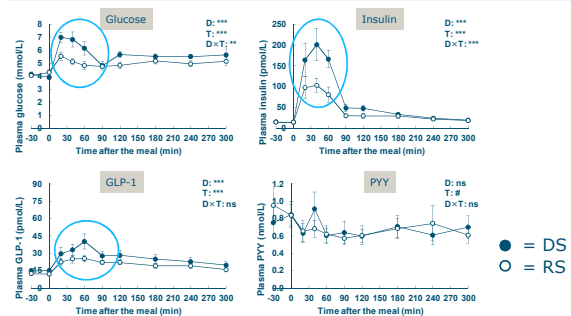
SCFA concentrations



Significantly increased colonic and plasma SCFA concentrations after RS consumption.



Postprandial plasma kinetics



- Blunted glucose, insulin and GLP-1 response with RS
- PYY concentrations not affected by diet



Conclusions

- Resistant starch shifted **NSP fermentation** to more distal parts of the colon.
- This **integrated study** has shown that **detailed analysis of fibre degradation, microbiota composition, and gene expression** is essential in dietary fibre research.
- Possible mechanisms responsible for the enhancement of **satiety** remain to be elucidated.
- Additional research** with other (fermentable) fibres and fibre dose-response relationship is required to confirm the hypothesised mechanisms.



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