Acute and semi-acute effects on glucose regulation – studies on rye and barley

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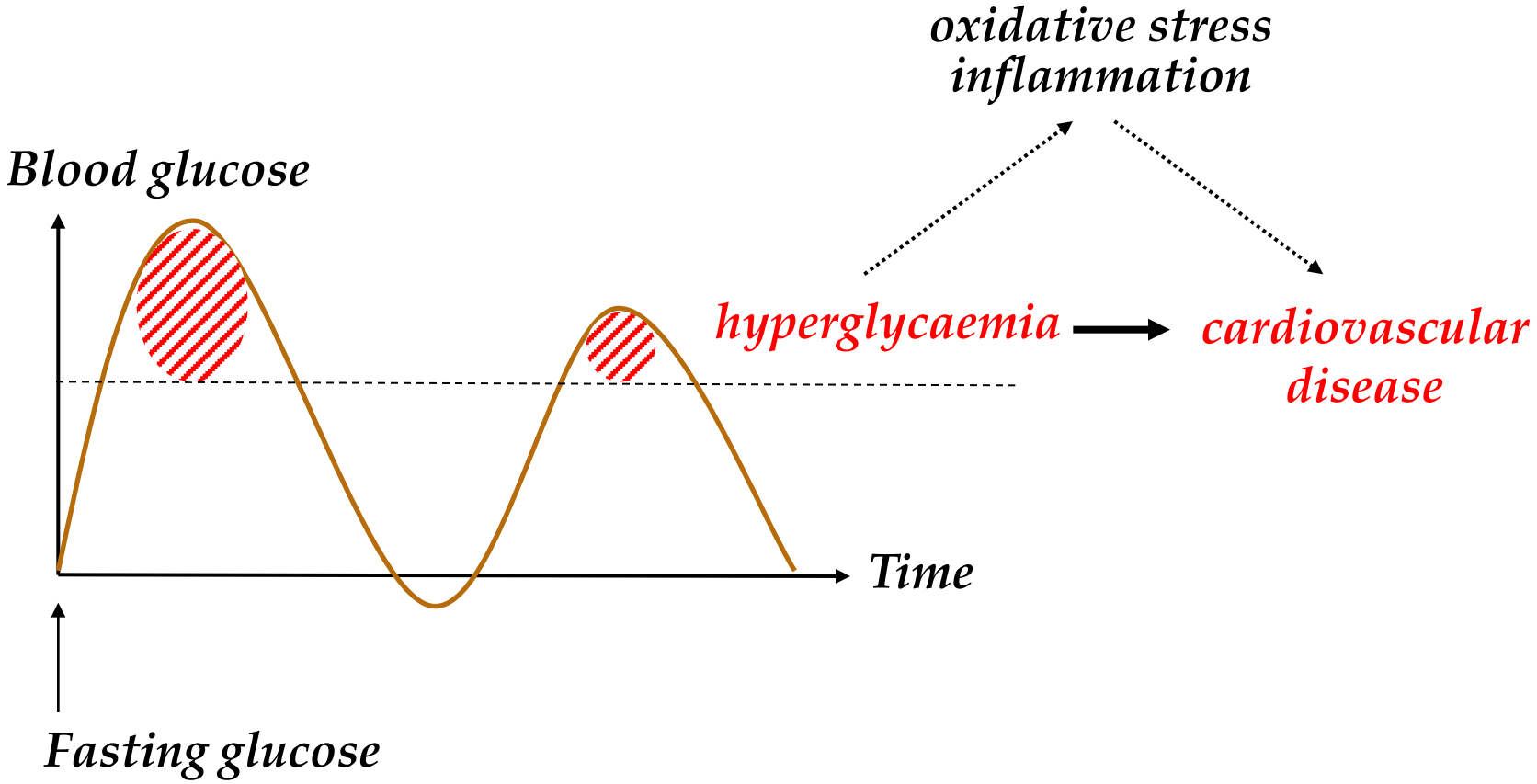
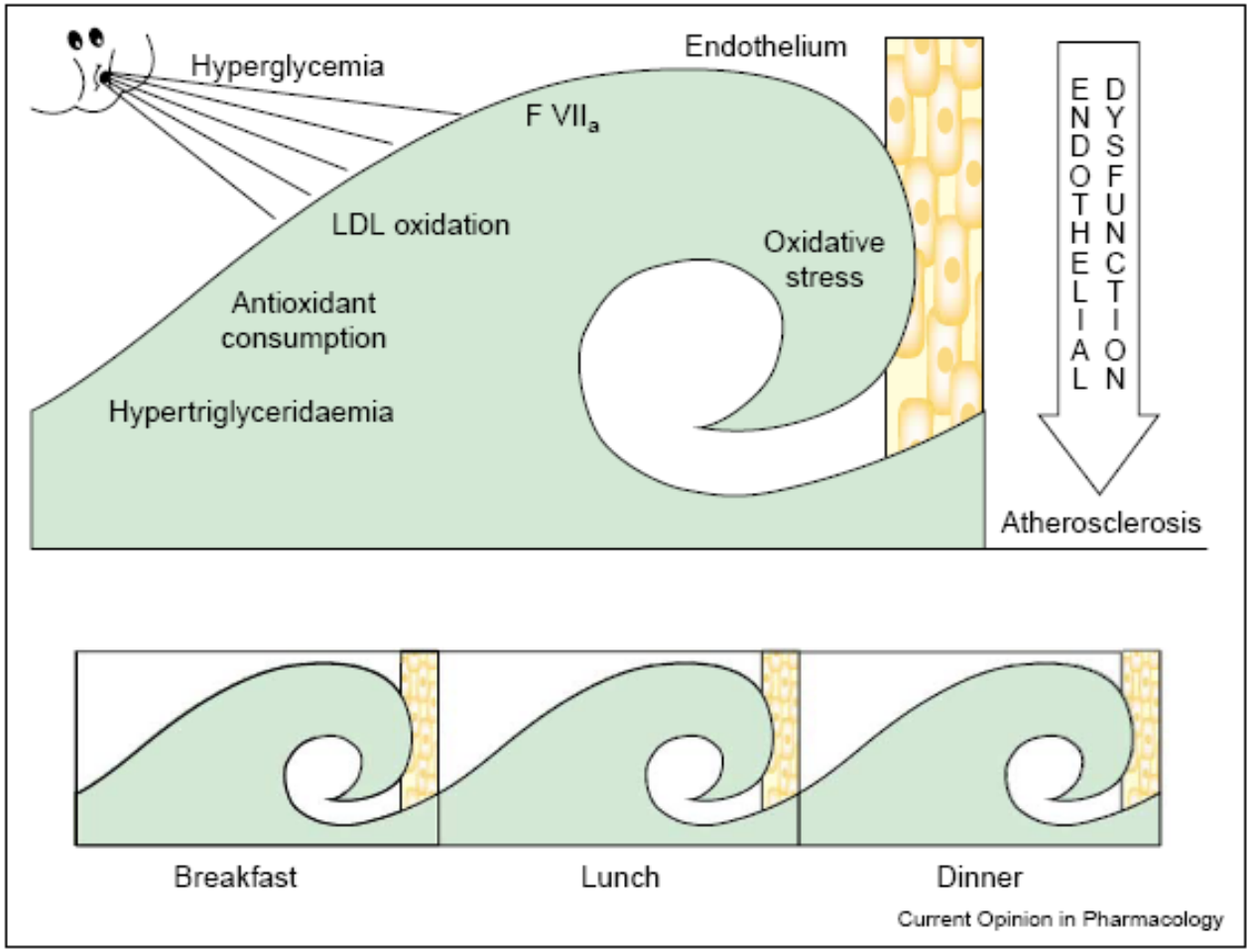
Importance of glycaemic regulation



Interaction between hyperglycaemia & oxidative stress



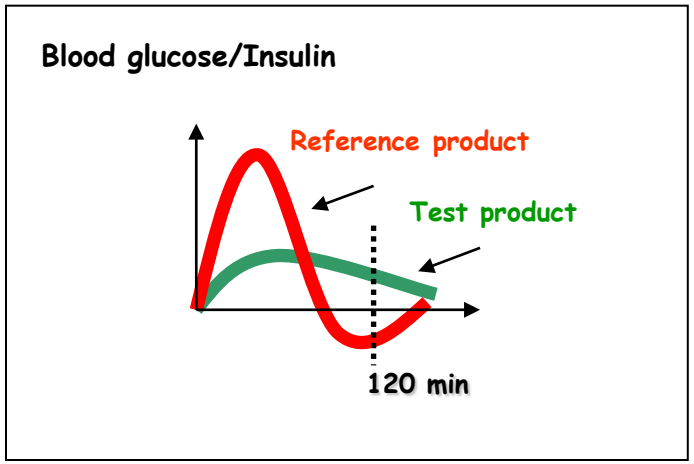
Oxidative stress affects e.g.
IL-6
CRP
Adiponectin

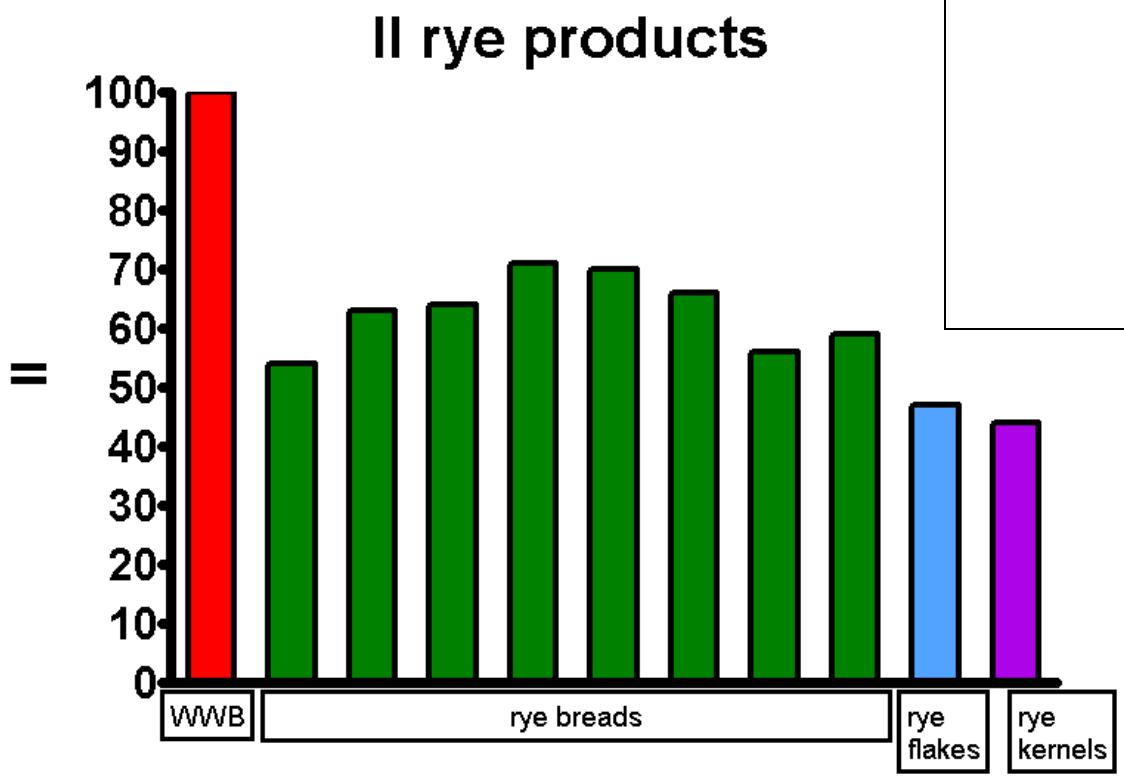
Image borrowed from Ceriello, *Diab Metab Res Rev*, 2000;16:125-132

How can postprandial glycaemia be lowered?

- Slower digestion and uptake
  - Reduced rate of gastric emptying (*e.g.* acetic acid)
  - Inhibition of digestive enzymes (*e.g.* Acarbose)
  - Slow release of starch from food matrix (*e.g.* dense structures, fibre-induced viscosity)
- Improved insulin economy/insulin sensitivity
  - Protein induced insulin secretion (*e.g.* whey)
  - ”Rye factor”

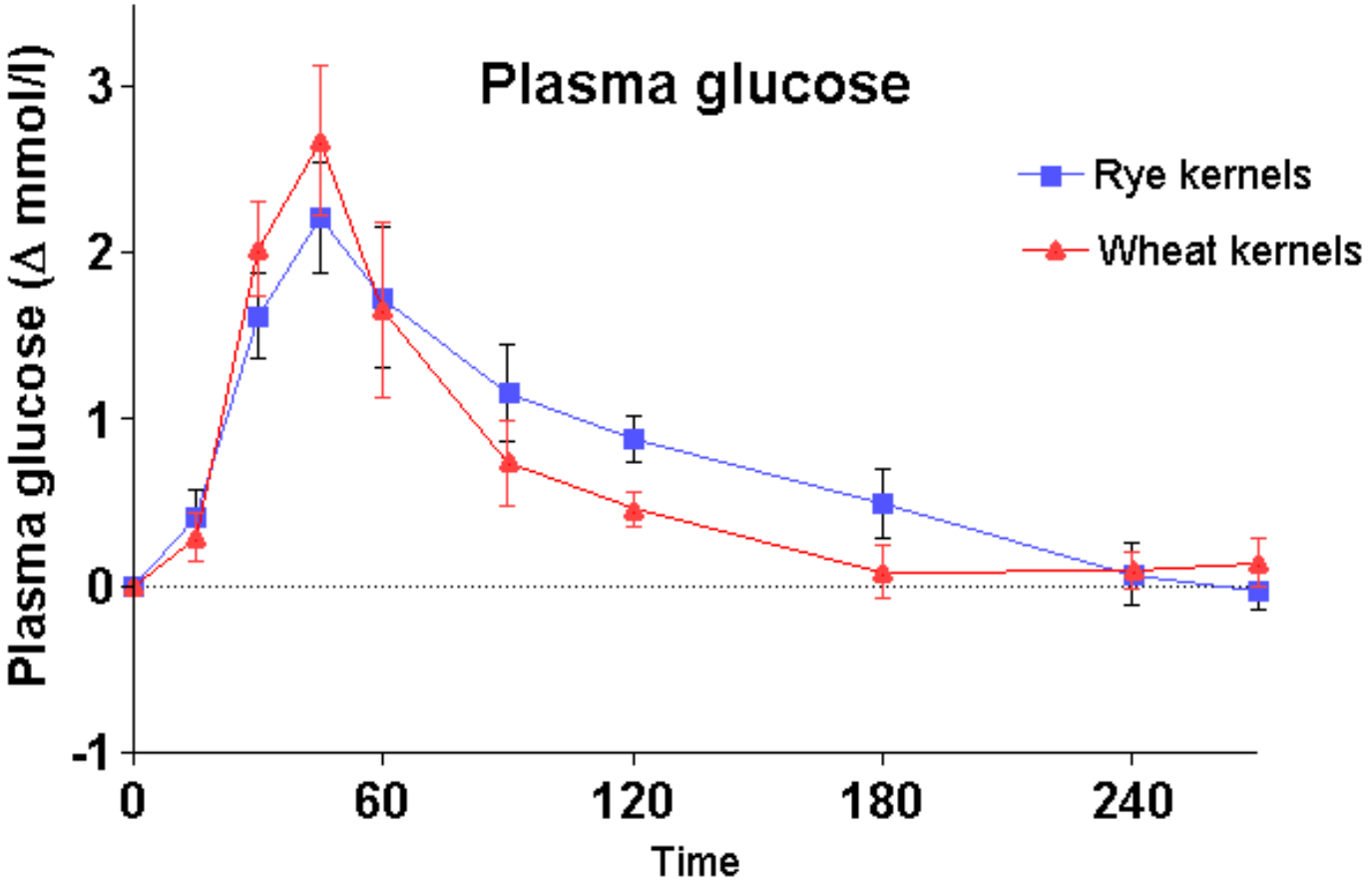
Acute insulin responses to rye products





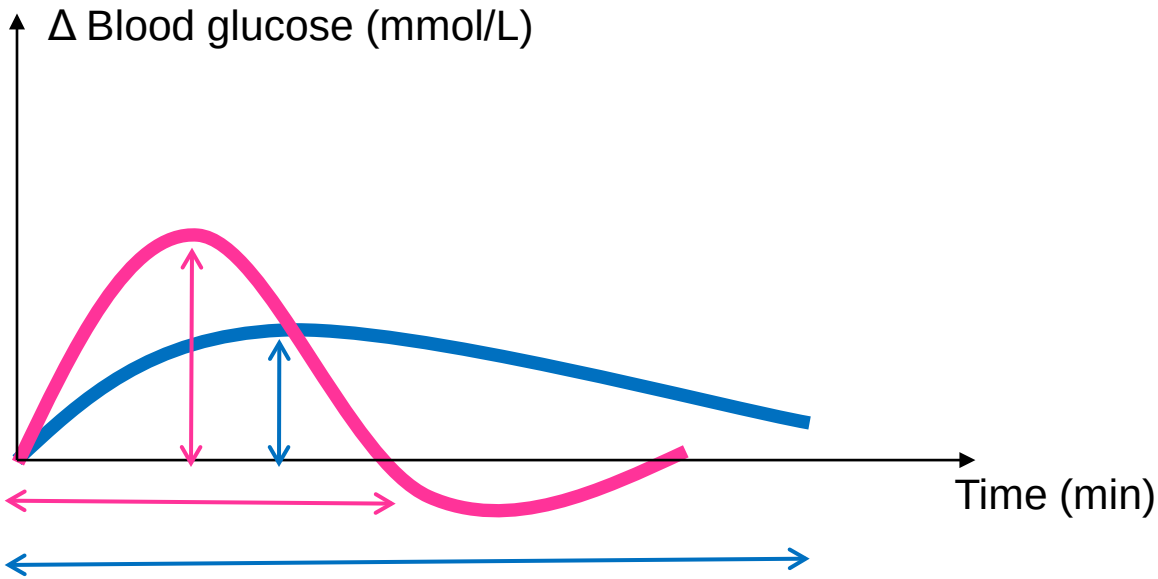
Rye products tested at Lund University

Late glucose increments with rye products



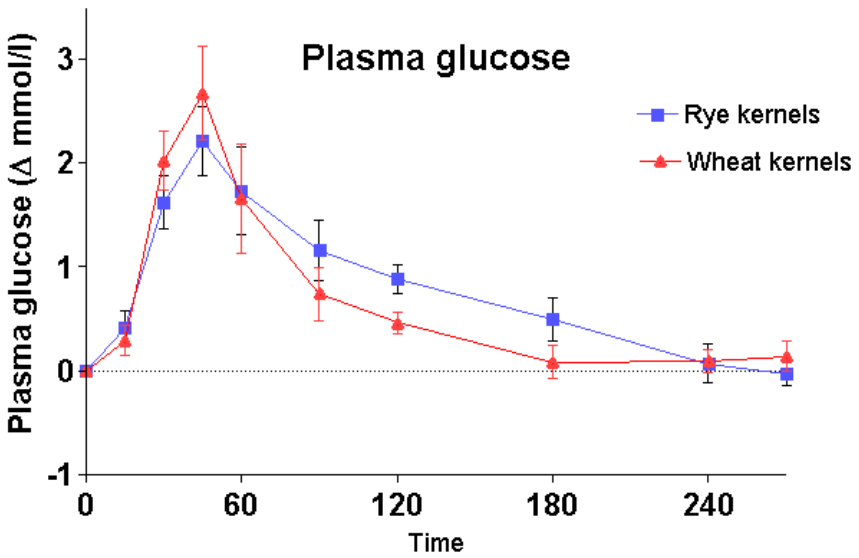
Calculation of Glycaemic profile

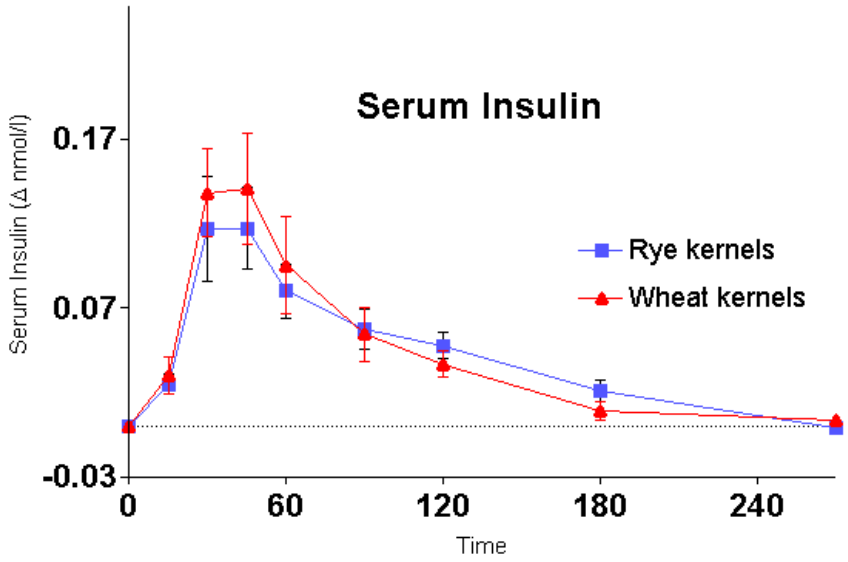
Glycaemic profile: GP = duration/peak (mM/min)



Rosén et al, Nutr J, 2009

Glycaemic profile as a complement to GI

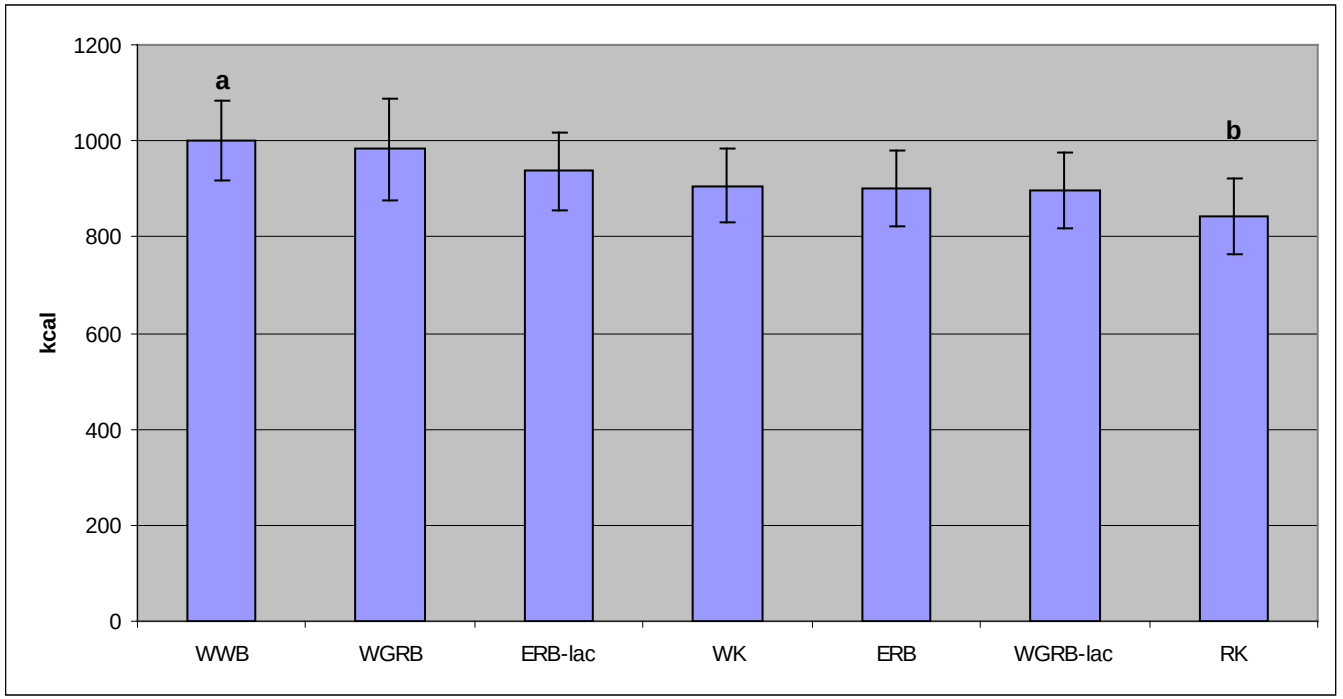




	Rye kernels	Wheat kernels
Glycaemic index	73 ± 8.4	68 ± 9.4
GP (*the higher the better*)	94 ± 12.6 [a]	51 ± 7.0 [b]

Rosén et al, *manuscript*

Voluntary lunch intake after rye or wheat breakfast meals

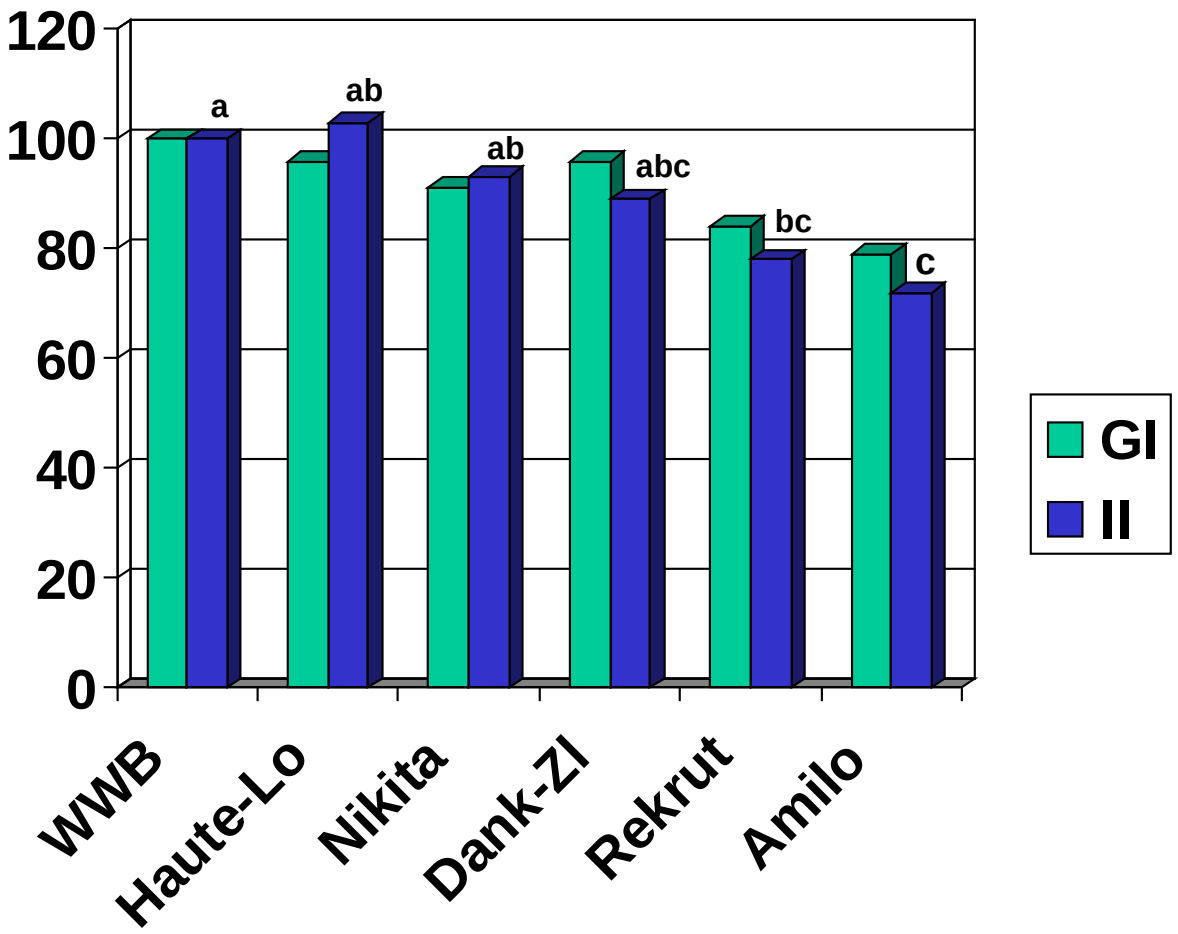


Rye kernels => 16% less energy intake at lunch than WWB

RK induced satiety at two subsequent meals (breakfast and lunch) compared to the white wheat bread breakfast.

Rosén et al, *manuscript*

Effects of 5 rye genotypes on glucose and insulin responses

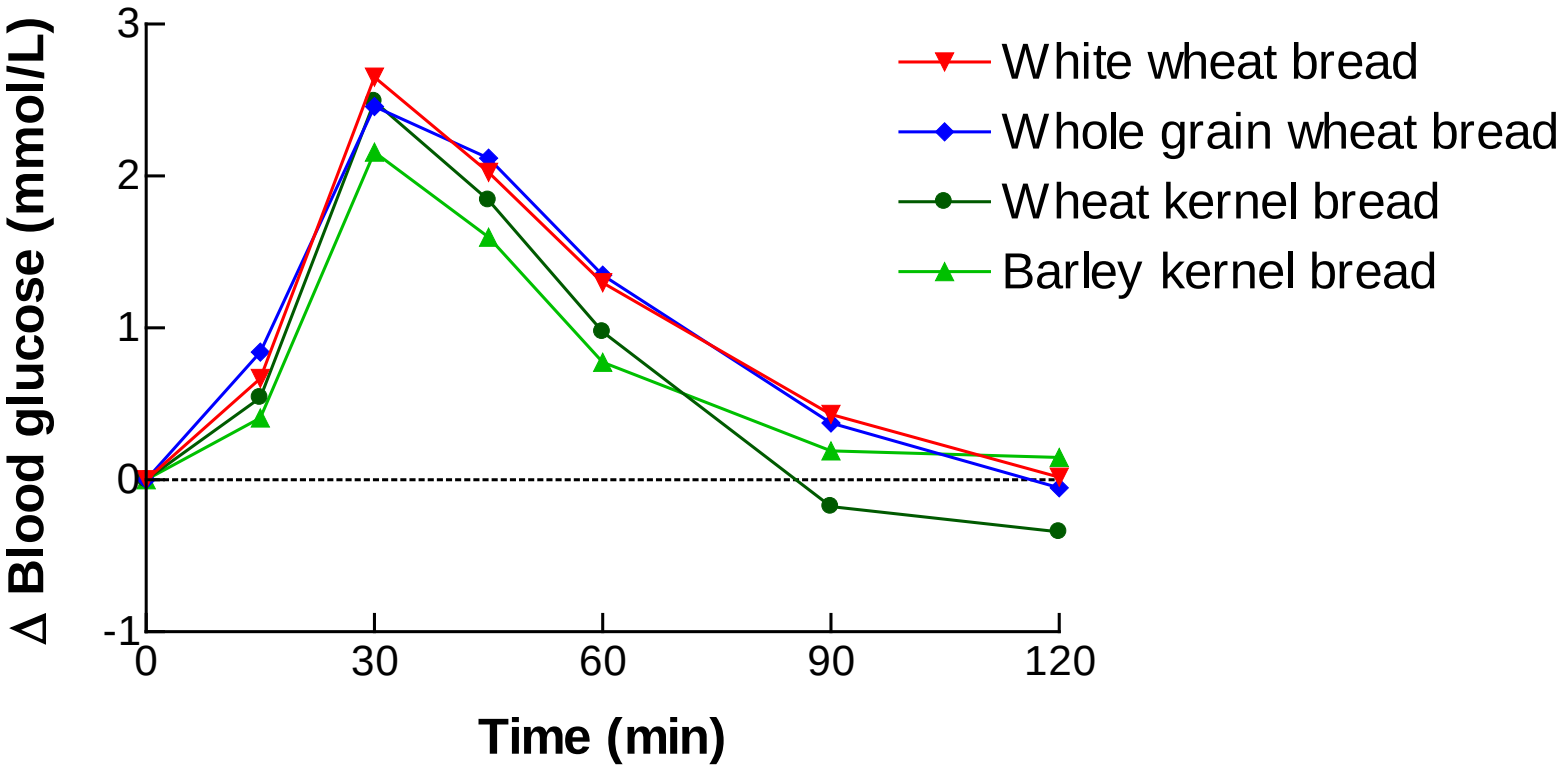


Rosén et al, *manuscript*

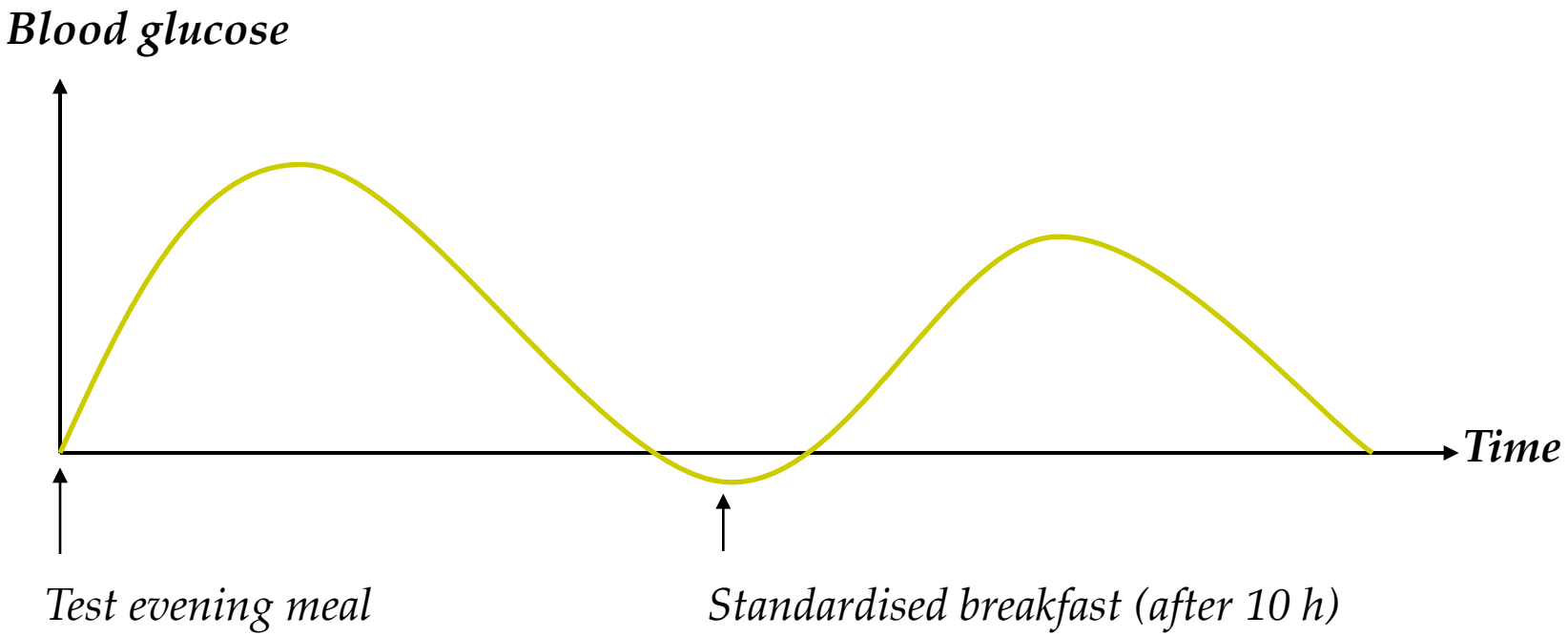
Influence of bioactive components on glucose and insulin responses to rye bread

- Increased levels of total **alkylresorcinols** was correlated with lower peak values on glucose and insulin
- Increased levels of total **folate** decreased glucose peak
- Increased levels of total **tocols** was associated with increased glucose and insulin responses
- **Sterols** varied in their effect on glucose and insulin
- High amounts of **phenolic acids** in general and soluble phenolic acid in particular, were correlated with improved glycaemic profiles and lowered insulin responses.

Glucose responses to wheat and barley bread



Semi-acute study of barley bread



Bread products included in overnight study

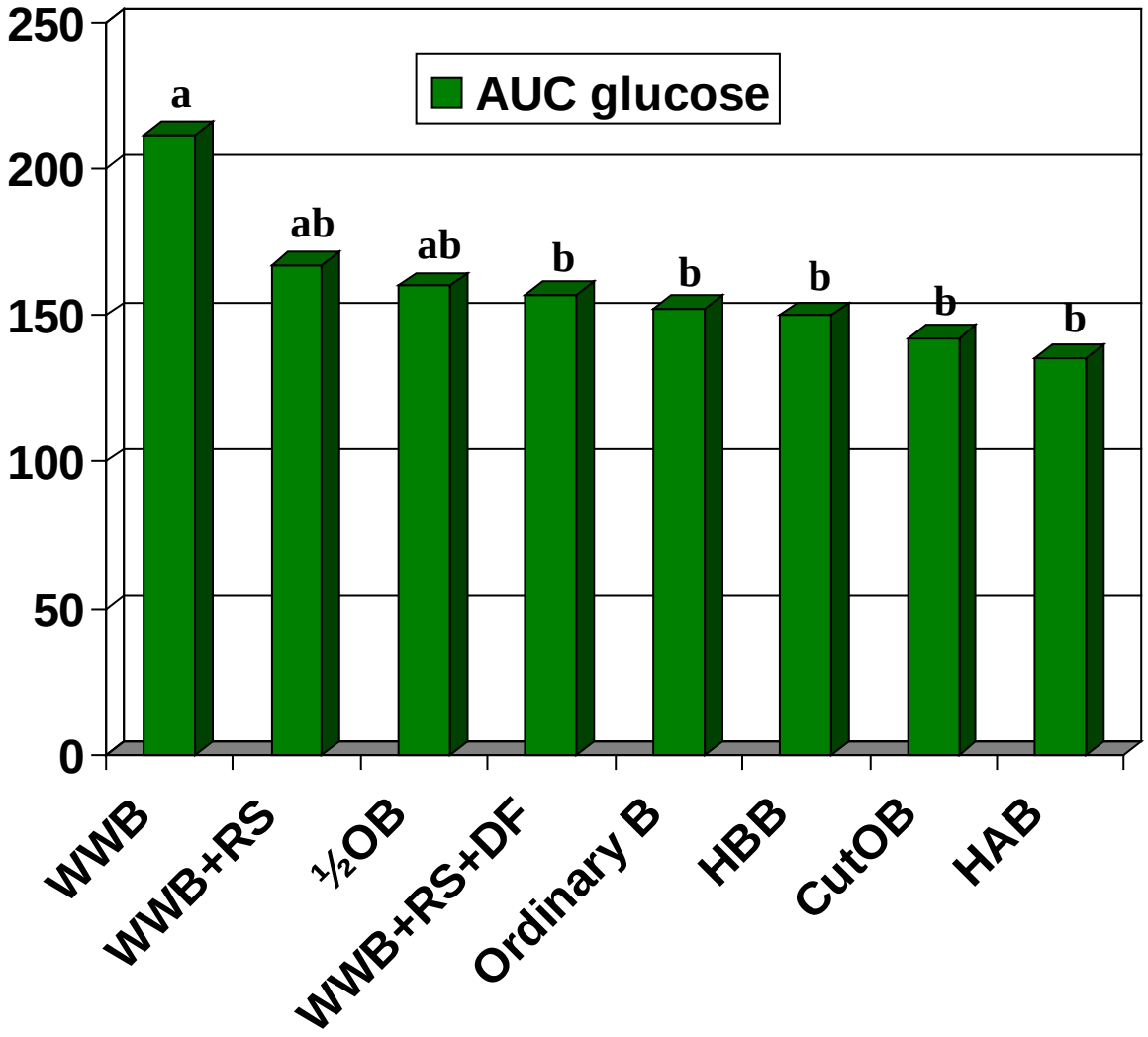
- White wheat bread (WWB), reference product
- Ordinary barley kernels (OB)
- Barley with elevated levels of amylose (HAB)
- Barley with elevated levels of beta-glucans (HBB)
- WWB + resistant starch (RS) from corn (Hi-maize)
- WWB + RS + dietary fibre (DF) from barley
- Ordinary barley kernels cut 1-2 times (CutOB)
- Half a portion of OB (½OB)

90% kernels and 10% white wheat flour

Study design

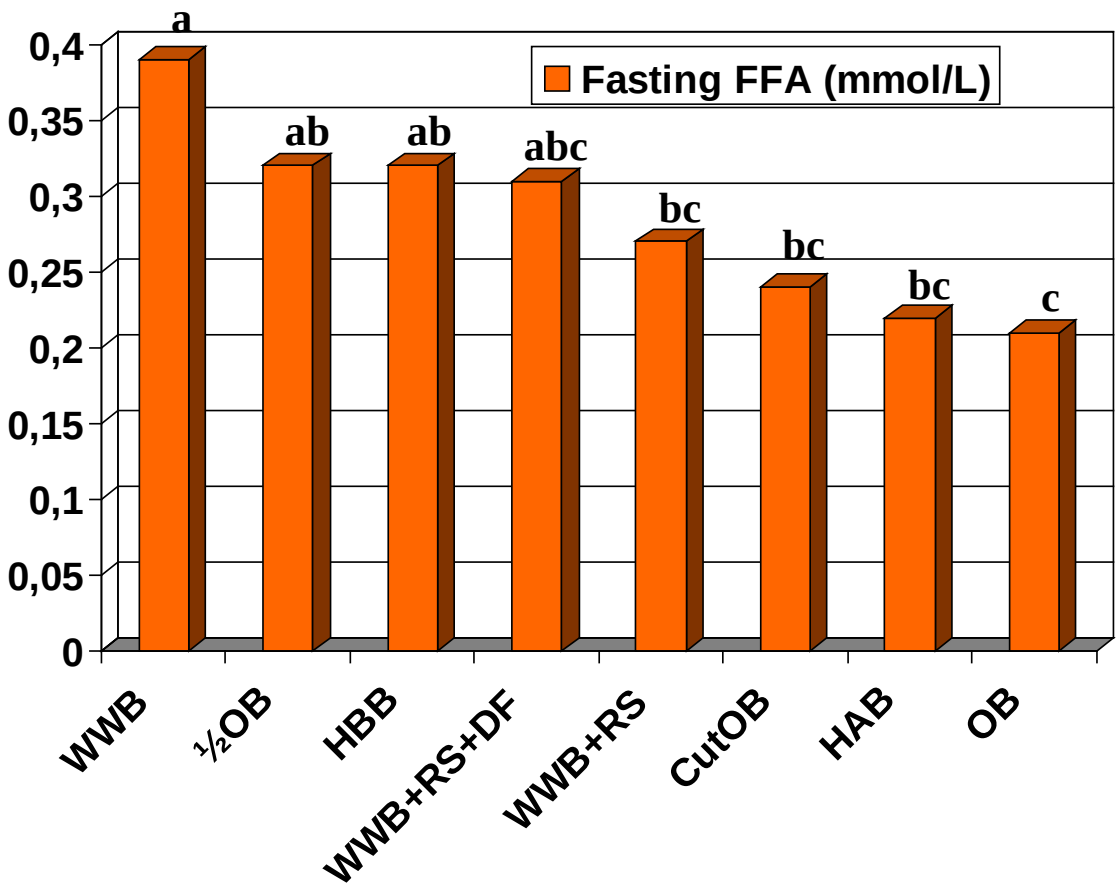
- 15 healthy subjects (4 women and 11 men)
- Age 22-32 years, mean BMI 22,5 kg/m^2
- Test products consumed as a late evening meal (0930 pm)
- Arrived fasting at standardised breakfast (0745 am)
- Fasting blood samples were taken before breakfast
- Satiety and breath hydrogen excretion registered at fasting
- Always white wheat bread (WWB) for breakfast
- Paracetamol in WWB as marker of gastric emptying
- Sampling performed during 3h after breakfast

Glucose responses at breakfast following different evening meals



Nilsson et al, *J Nutr* 138;732-739, 2008

Fasting levels of free fatty acids in the morning following different evening meals



Nilsson et al, *J Nutr* 138;732-739, 2008

Associations between glycaemia and colonic fermentation

- Increased GLP-1 at breakfast was associated with lower glucose response
- Increased breath hydrogen at breakfast was associated with lower glucose response
- Increased plasma butyrate at fasting was associated with lower glucose and insulin responses after breakfast
- Increased plasma acetate (mean of 0 & 30 min) was associated with lowered glucose responses at breakfast

Effects on markers of inflammation

- **Adiponectin** (anti-inflammatory marker)
  - Fasting concentrations significantly higher following Ordinary Barley bread compared with WWB.
  - Reported to promote clearance of FFA and thus improve insulin sensitivity

- **Interleukin 6** (inflammatory marker)
  - Mean value (0-180 min) after breakfast was significantly lower after OB evening meal than after the WWB evening meal

Conclusions from semi-acute study on barley

The presence of specific prebiotics in an evening meal beneficially affected glucose tolerance and related risk markers after the following breakfast

The beneficial overnight effect on glucose tolerance seen with intact barley kernels could be mimicked by adding a corresponding amount of RS and barley DF to white bread

The prebiotic characteristics of the evening meal importantly affected the levels of the incretine hormone GLP-1 as well as butyrate at breakfast, both showing an inverse relation to the glycaemic response at breakfast

Overall conclusions

- Glyceamic profile is an important complement to the GI
- Improved postprandial glycaemic profile lowers energy intake at a following meal
- Important to include endosperm in rye products for benefits on glucose regulation
- Whole grain barley products improve glucose tolerance both acute and semi-acute
- By combining certain indigestible carbohydrates, also flour based products can improve overnight glucose tolerance
- Colonic fermentation of indigestible carbohydrates important in longer term glucose and appetite regulation