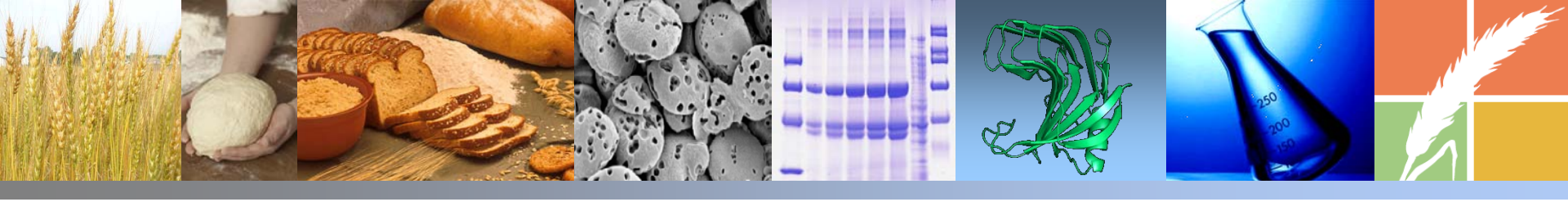

Matching technological and nutritional benefits: the arabinoxylan-oligosaccharide case

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Healthgrain Open Conference, Lund, Sweden
May 6, 2010

Presentation overview

- Introduction and scope
- Production of wheat bran AXOS
- *In situ* AXOS production in bread
- General conclusions

Introduction

Functional foods and ingredients

- Interest in functional foods and functional ingredients
- In the past: a lot of attention on the technological properties and impact of arabinoxylans (AX) in cereal based processes
  - Selected xylanases improve processing and end products
- More recent: interest in the nutritional importance of AX as part of whole grain
  - WU-AX: insoluble dietary fibre, water holding, bulking agent
  - WE-AX: soluble dietary fibre, highly viscosifying

But: what about wheat derived arabinoxylan-oligosaccharides (AXOS)?

Introduction

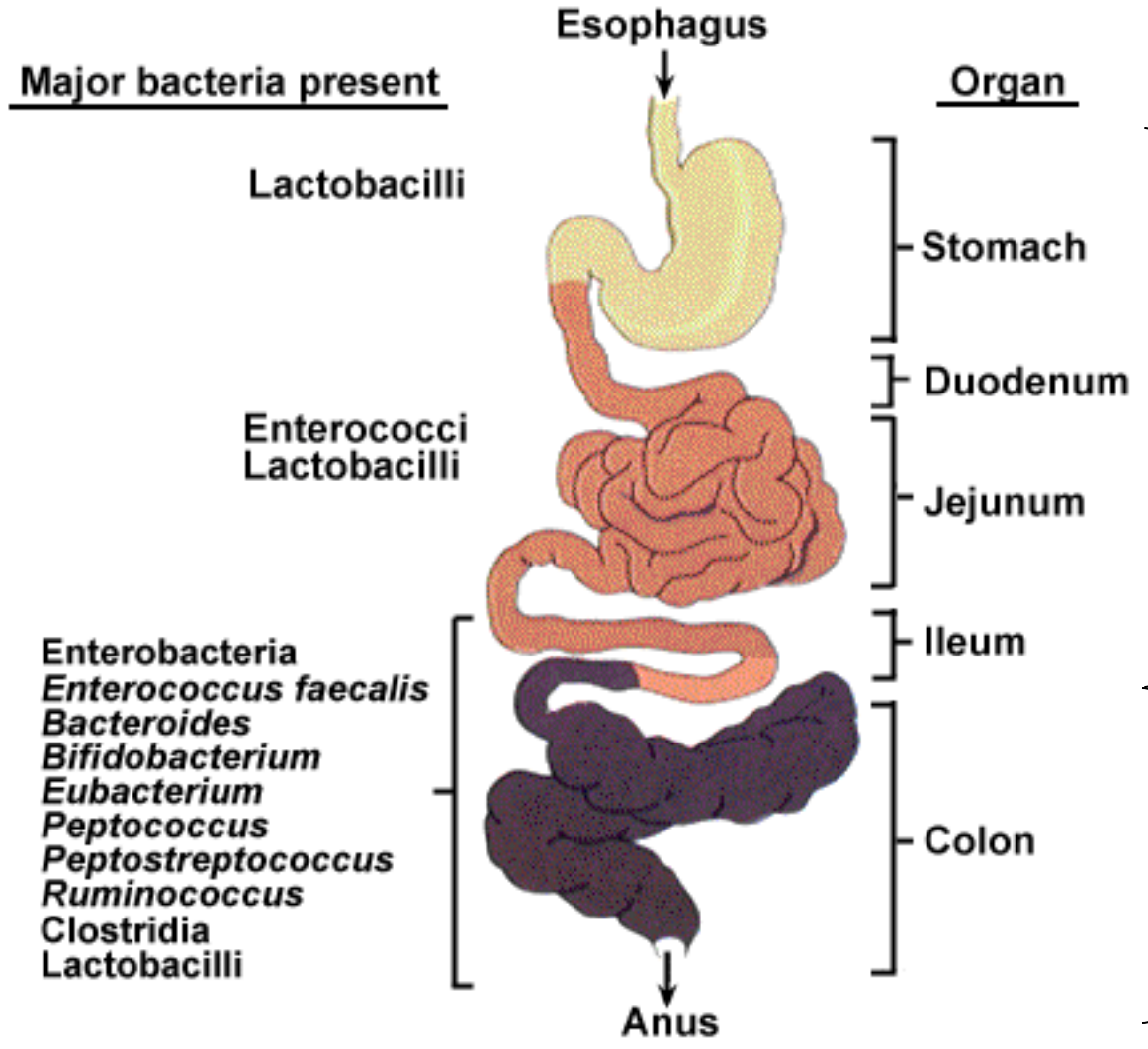
Functional foods and ingredients

- Suggestion that AXOS act as prebiotics

- Prebiotics?
  - One type of functional food ingredients
  - Non-digestible food components that affect the host in a beneficial way by selectively stimulating growth and/or activity of one or a limited number of bacteria in the colon such as Bifidobacteria or Lactobacilli (Gibson et al. 2004)
  - Mainly non-digestible oligosaccharides (e.g. inulin, fructo-, galacto- and xylooligosaccharides)

Introduction

Functional food ingredients: prebiotics



Prebiotics

⇩

No degradation by gastrointestinal enzymes (low caloric content)

⇩

Fermentation by and selective stimulation of “good” bacteria that can degrade prebiotic compound

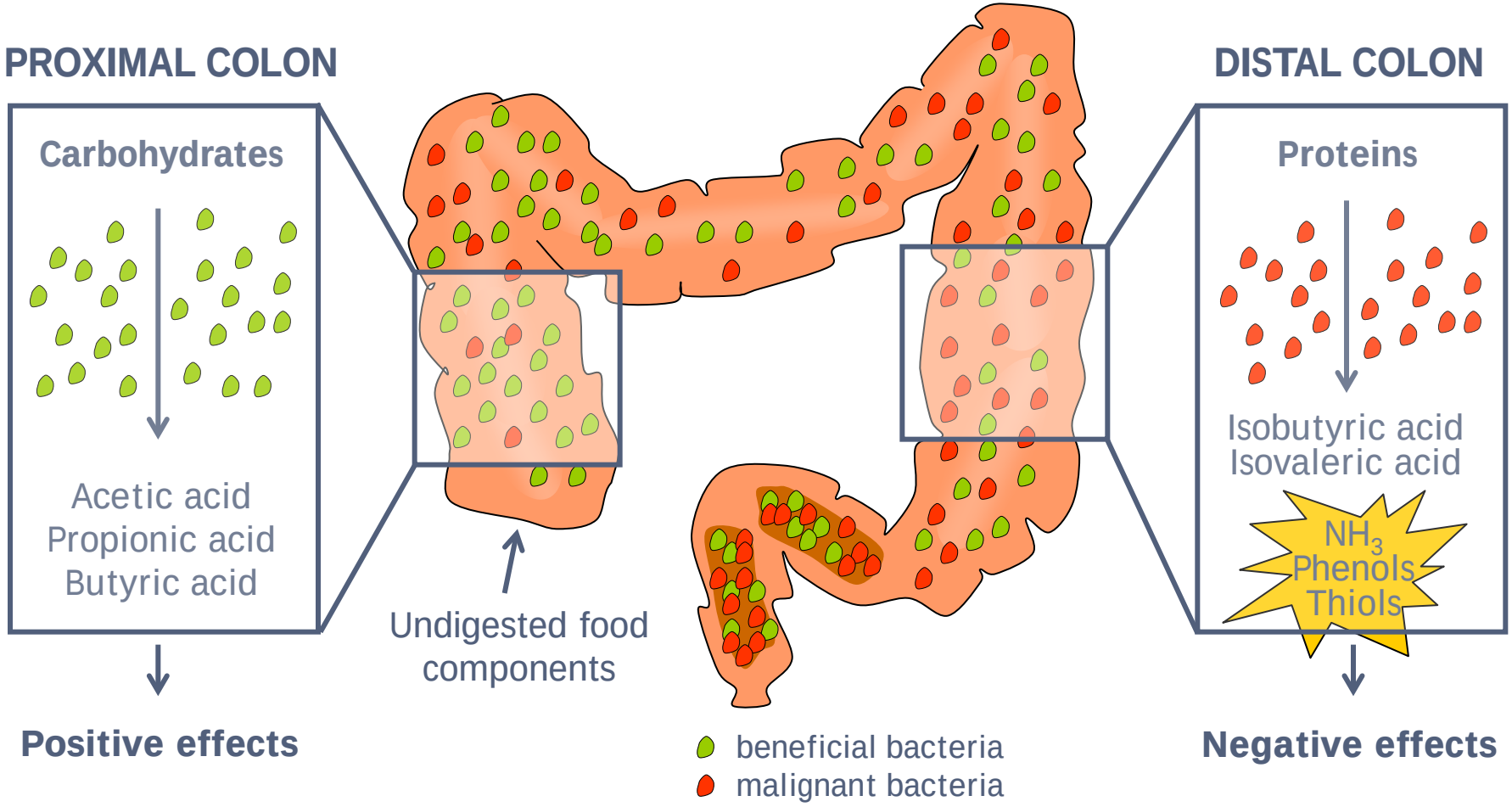
⇩

Health benefit

Introduction

Functional food ingredients: prebiotics

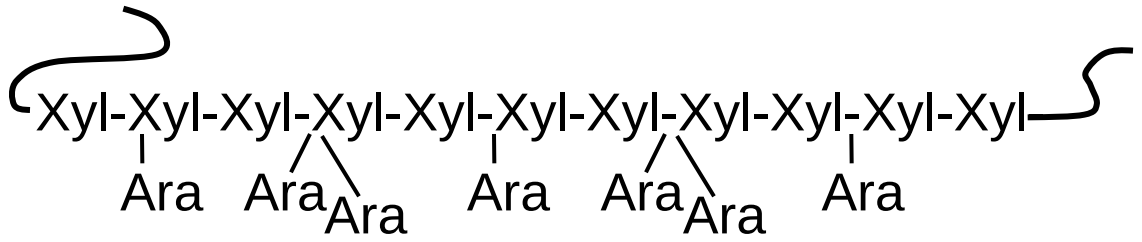
- Fermentation in the human colon



Introduction

Functional food ingredients: prebiotics

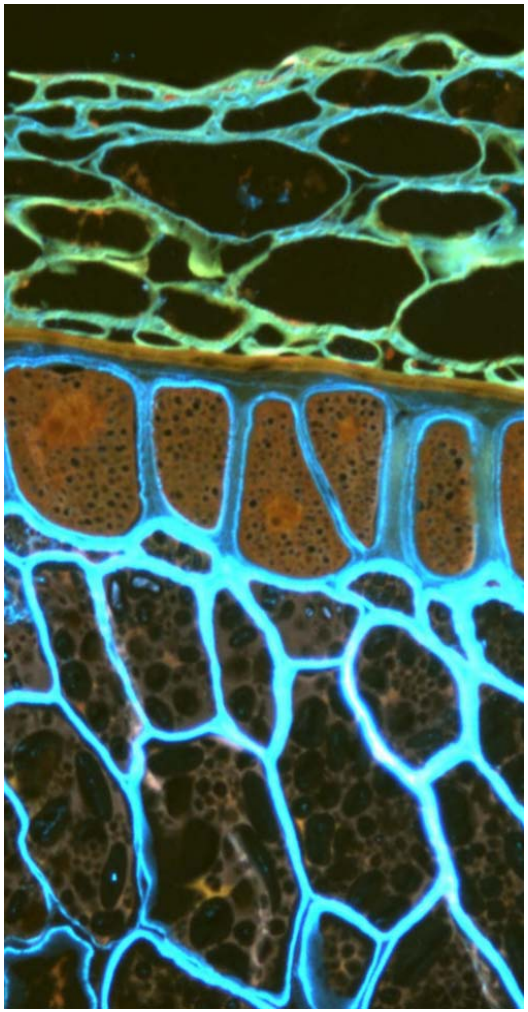
Arabinoxylan



Mol. Mass: 800,000 Da

Introduction

Functional food ingredients: prebiotics



Wheat 4 – 7 % AX – A/X: 0.55

Fruit coat (pericarp) 40% AX – A/X: 1.1

Seed coat (testa) 40% AX – A/X: 0.10

Aleurone layer 30% AX – A/X: 0.35

Technical bran
35% AX - 0.55

Starchy endosperm 2% AX – A/X: 0.55

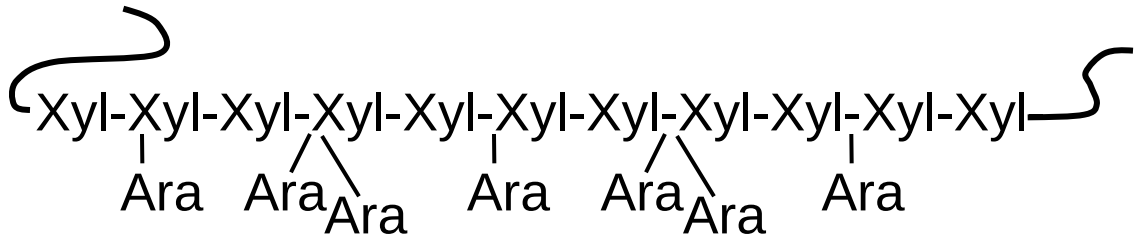
Red: protein, blue: cell walls, yellow: lignified cell walls

Slide courtesy of
Dr. Karin Autio,
VTT, Finland

Introduction

Functional food ingredients: prebiotics

Arabinoxylan



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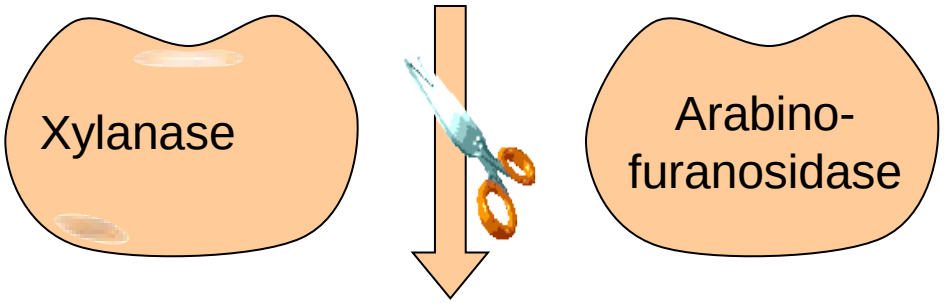
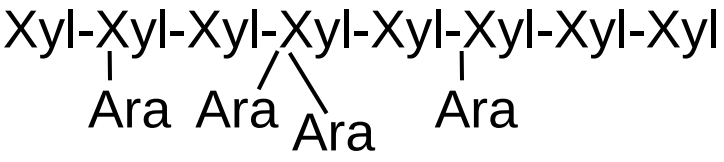
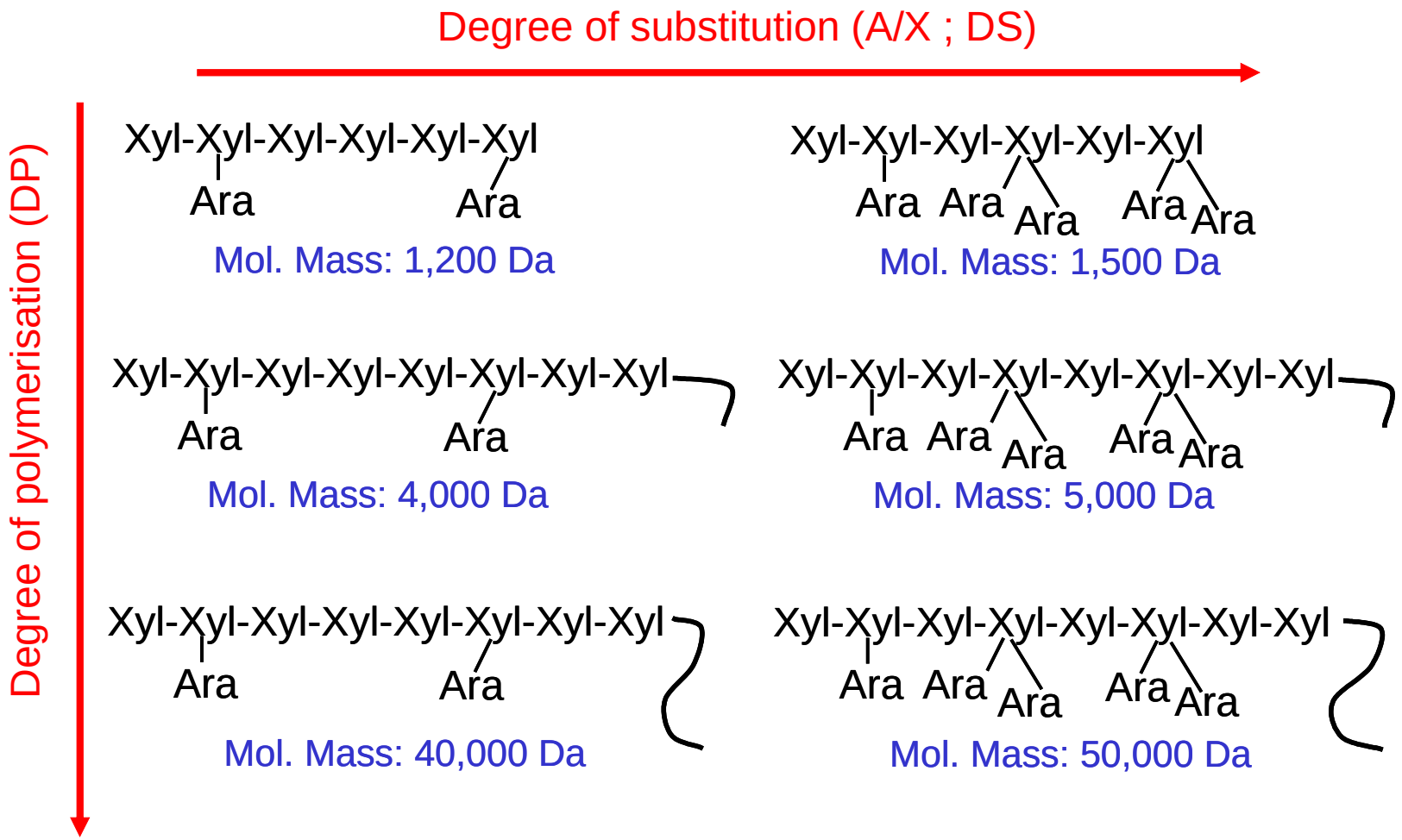


Arabinoxylo-oligosaccharide (AXOS)



Introduction

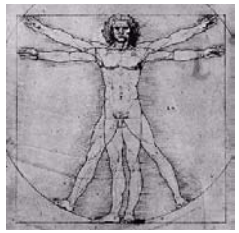
Functional food ingredients: prebiotics



Introduction

Functional food ingredients: prebiotics

- Over the past 5 years, we were able to show:
  - Fermentation of AXOS with the production of short chain fatty acids & selective stimulation of bacteria in rat trials; structure dependency
  - Less preneoplastic lesions in the distal colon of rats through the administration of AXOS
  - Much less translocation of pathogens to the spleen upon infection in chicken trials
  - Increase of efficiency of food utilisation in chicken feeding trials
  - Extension of carbohydrate fermentation to the distal colon to the disadvantage of protein fermentation in humans
  - High tolerance levels in humans



Introduction

Functional food ingredients: prebiotics

- Additional evidence for prebiotic effect of AXOS from
  - *In vitro* tests (monocultures, SHIME, …)
  - *In vivo* trials (human, chicken, rat trials)
  - Literature

⇨ AXOS works as a prebiotic

⇨ Results suggest a dosage of 2.0 to 2.5 g / day for physiological effect in humans

How can we supply 2.5 g AXOS / day?

Scope of this presentation

To illustrate how we can possibly improve the nutritional profile of grain products, *in casu* bread, by using xylanase technology and the AXOS concept

Presentation overview

- Introduction and scope
- Production of wheat bran AXOS
- *In situ* AXOS production in bread
- General conclusions

Production of AXOS from wheat bran

Wheat bran

↓ Amylase-treatment
Protease-treatment
Filtration

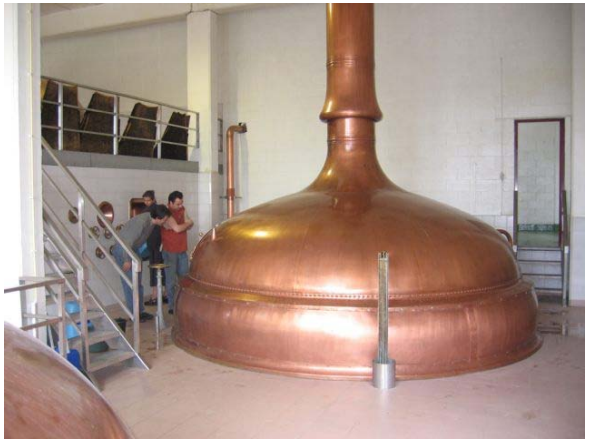
Destarched, deproteinised wheat bran

↓ **Xylanase-treatment**
Filtration

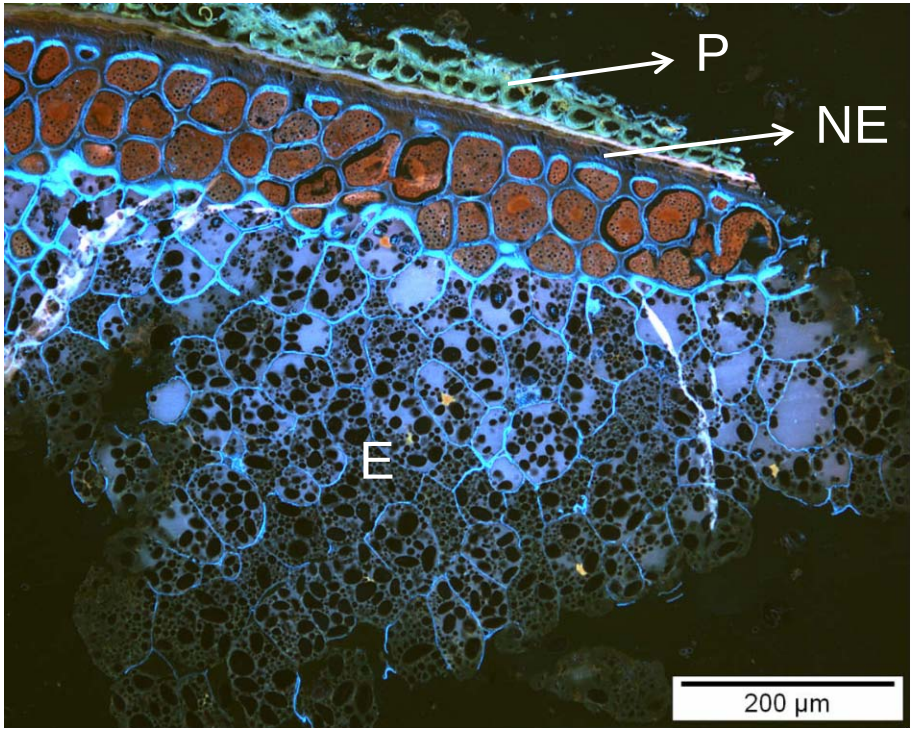
Supernatant of wheat bran AXOS

↓ Concentration
Evaporation
Spray drying

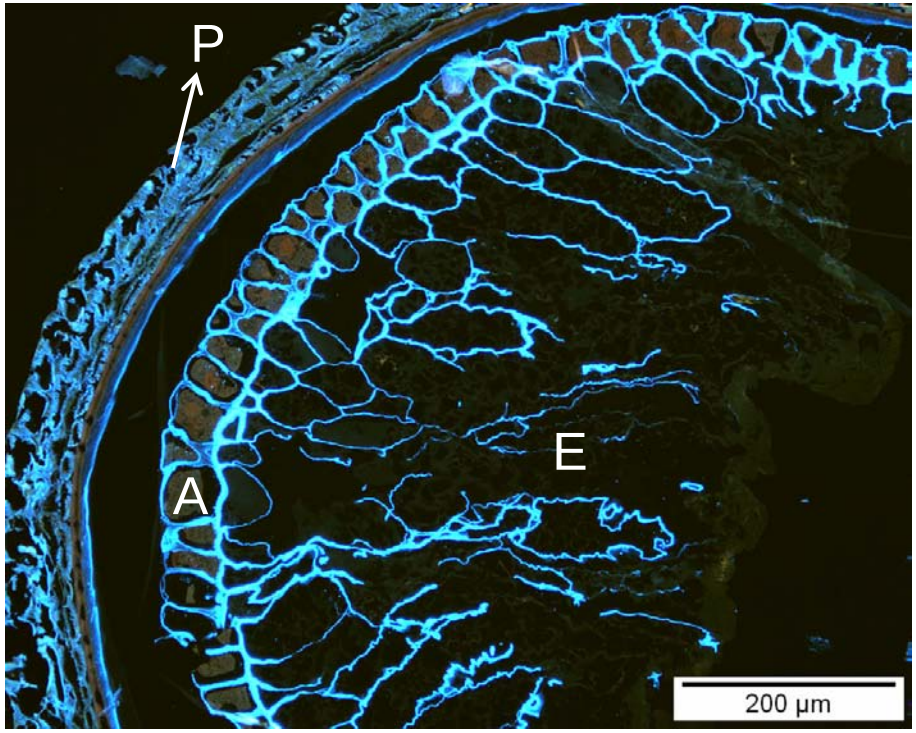
Wheat bran AXOS



Production of AXOS from wheat bran



Xylanase treatment



Pictures produced by
Dr. Emilia Selinheimo,
VTT, Finland

Production of AXOS from wheat bran

- AXOS preparation: purity of 85% and up
- Pilot scale production
- Possibility to include in all sorts of products such as bread

Picture courtesy of Elin Ostman (LU)
Very high level AXOS bread for nutritional test
(see poster)

Presentation overview

- Introduction
- Production of wheat bran AXOS
- *In situ* AXOS production in bread
- General conclusions

In situ AXOS production in bread

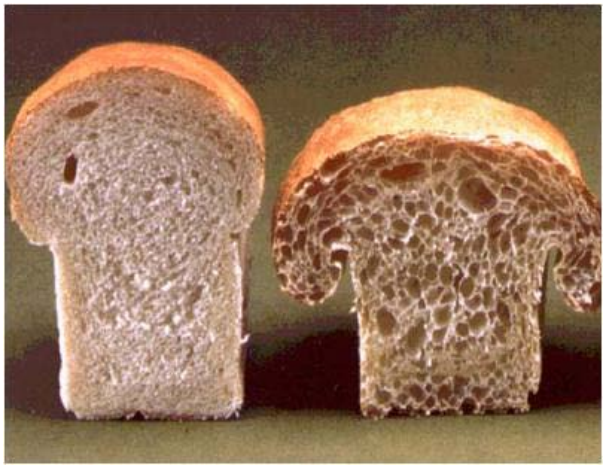
Unique opportunity

- Bread(making) = unique opportunity to introduce AXOS in the diet:
  - Presence of AX in the raw material
  - Xylanases provide possibility of *in situ* AXOS production
  - Xylanases are already in use in bread making
  - No need for AXOS as an ingredient

In situ AXOS production in bread

Challenges

- But:
  - AX content in starting material should be sufficiently high
    - White wheat flour contains only approx. 2% of AX
  - Average DP of AXOS should be low enough
  - Dough has to be manageable & bread has to be OK
    - Significant AX degradation gives rise to slack and sticky dough and ‘droopy’ breads



McCleary, 1986, Int. J. Biol. Macromol., 8: 349-354

In situ AXOS production in bread

Solution for AX content challenge

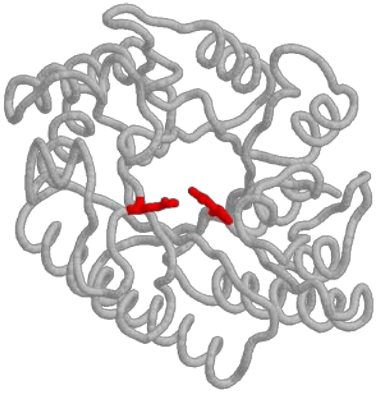
- Solution for AX content:
  - Use or introduce AX rich material under the form of
    - Whole meal
    - Bran from different cereal origins
    - Aleuron enriched material
    - AX enriched isolates
  - AX material should be (partially) degradable (low A/X ratio)
- Correction of the recipe necessary

- **Bonus: better nutritional profile of the bread**

In situ AXOS production in bread

Solution for the xylanase challenge

- Xylanases classified in Glycoside Hydrolase Families:
  - GHF 5: Large variety of enzymes; only a few xylanases
  - GHF 8: Large variety of enzymes; only a few xylanases
  - GHF 10: } Mostly xylanases, most common xylanases
  - GHF 11: }
  - GHF 43: Few multi-domain enzymes



GHF 10 xylanases

- Molecular mass: > 30 kDa
- Origin: fungal, bacterial and plant
- Structure:
  - $(\beta/\alpha)_8$-barrel or 'Salad bowl'
  - Catalytic & non-catalytic domains
- Specificity: catalytic diversity

GHF 11 xylanases

- Molecular mass: ca. 20 kDa
- Origin: fungal and bacterial
- Structure:
  - α-helix and 2 β-sheet or 'partly-closed right hand'
  - Single domain (catalytic domain)
- Specificity: little catalytic diversity

In situ AXOS production in bread

Solution for the xylanase challenge

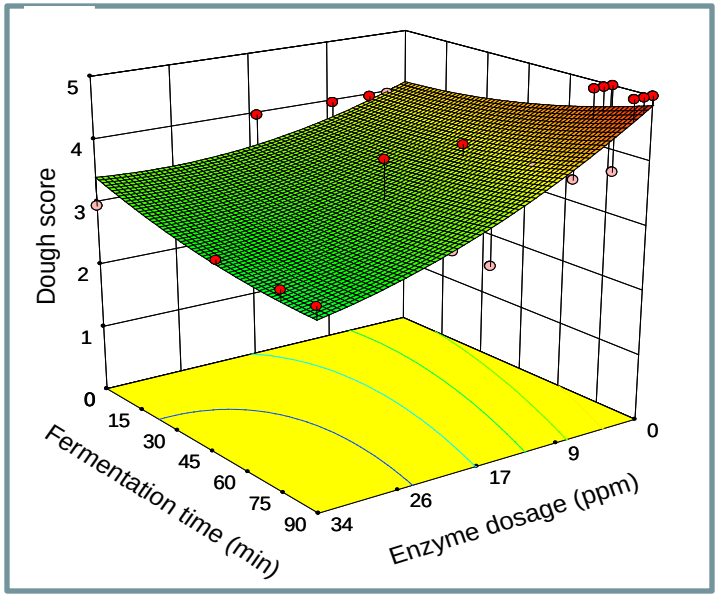
- Select and develop xylanases that
  - Work primarily in the baking phase of bread making and not during mixing and fermentation: thermophilic xylanases
  - Produce AXOS of sufficiently low molecular weight: the right specificity should be selected: GHF10 xylanases
  - Example: *Thermotoga martima* XynA and XynB xylanases
    - XynA: structure dependent T-optimum between 65 and 85°C
    - XynB: optimally active at 100°C

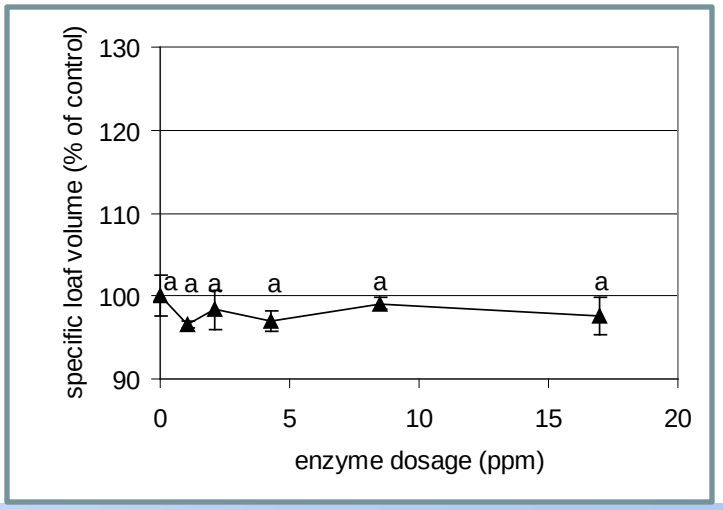
In situ AXOS production in bread

Results

- *T. maritima* XynB:
  - Almost no impact on dough manageability, even at very high concentrations
  - No impact on loaf volume
  - But: significant production of low DP AXOS!

  → Works only during baking
  - To our surprise: strong synergetic volume improving effect when used in combination with a breadmaking active xylanase

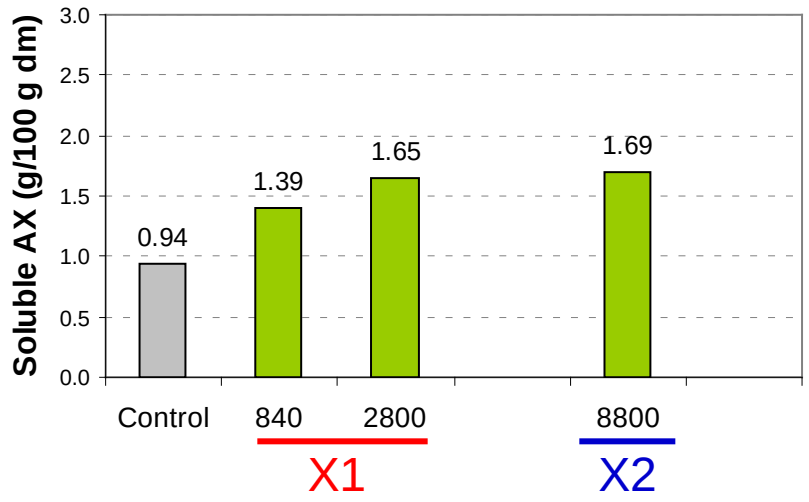


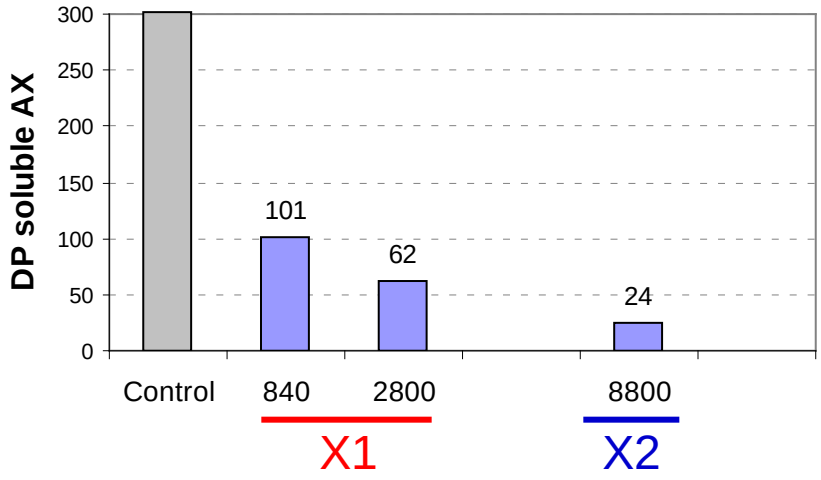


In situ AXOS production in bread

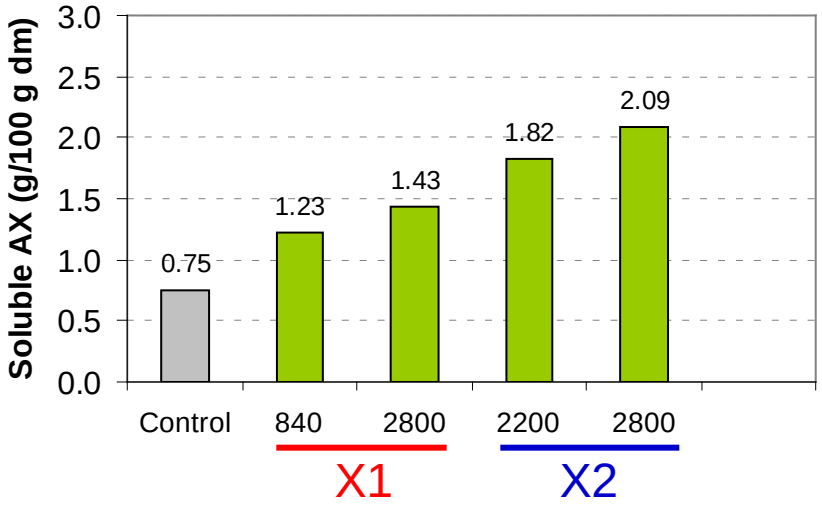
Results

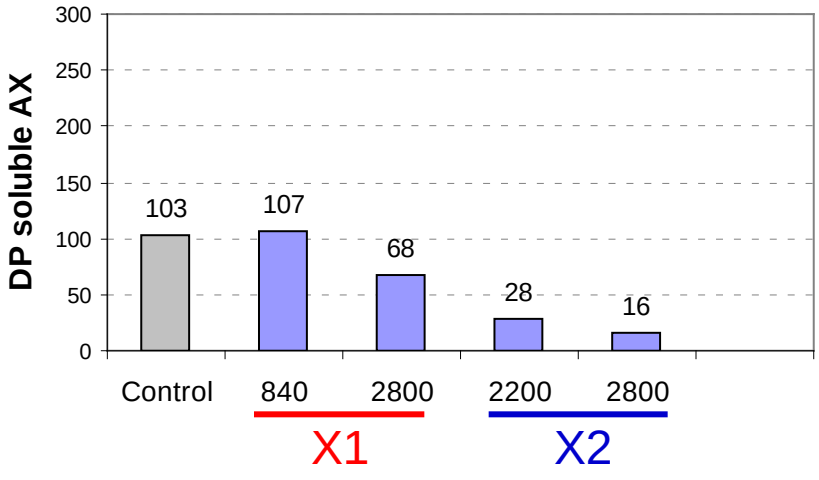
Wheat endosperm





Wheat wholegrain

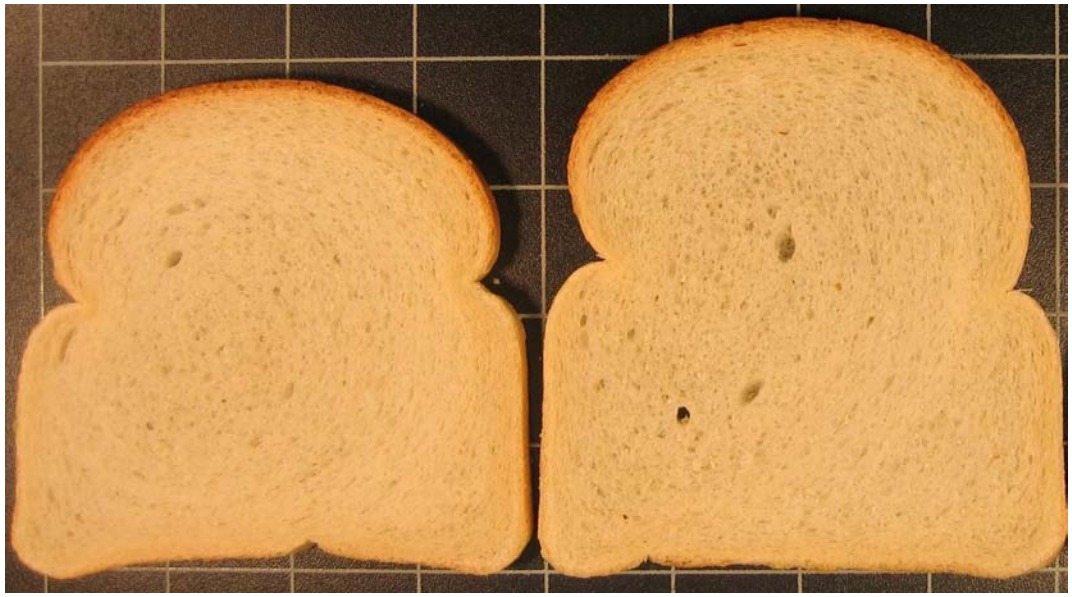




In situ AXOS production in bread

Results

Wheat endosperm flour



control
(avDP sol AX = 302)
(S-AX = 0.9%)

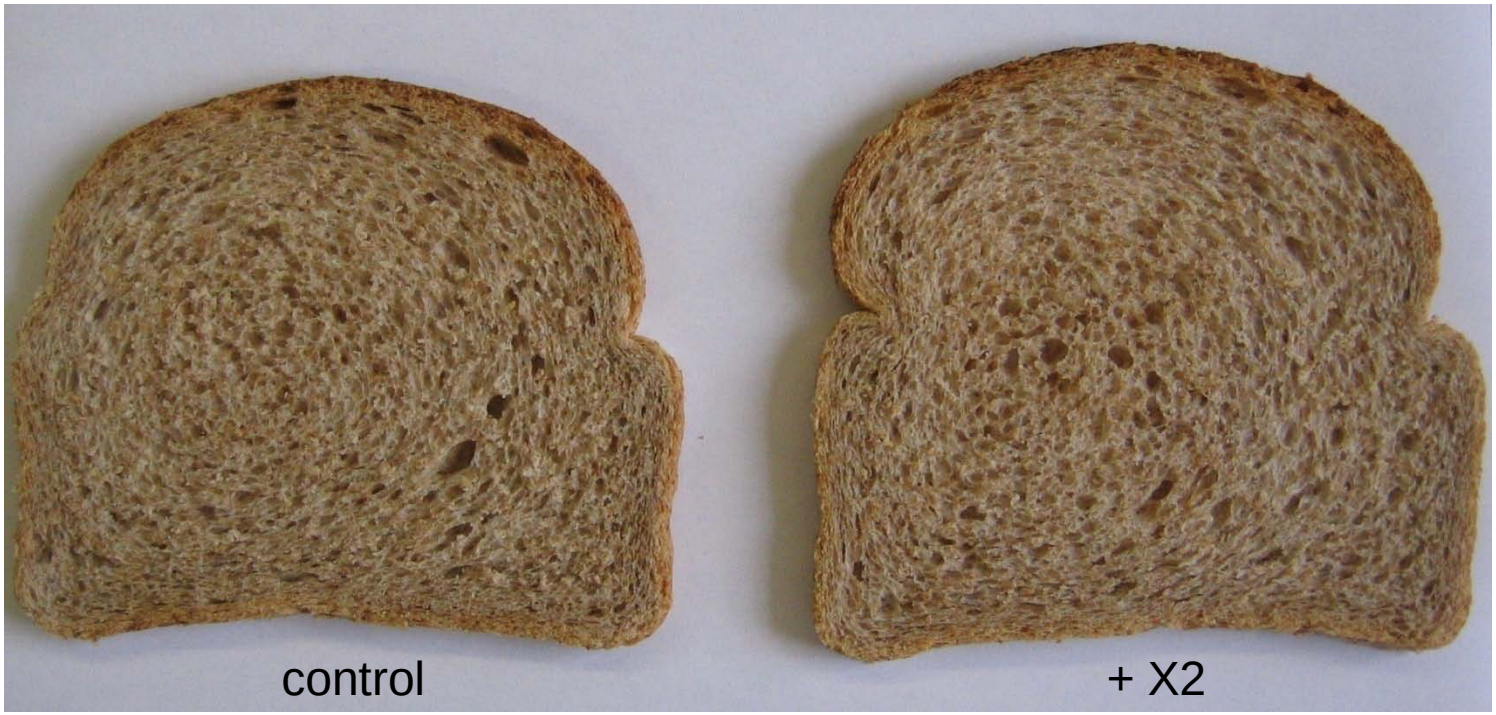
+ X2
(avDP sol AX = 24)
(S-AX = 1.7%)

In situ AXOS production in bread

Results

Matching the nutritional and the technological need!

Wheat wholemeal



control

avDP sol AX = 103

S-AX content = 0.7%

+ X2

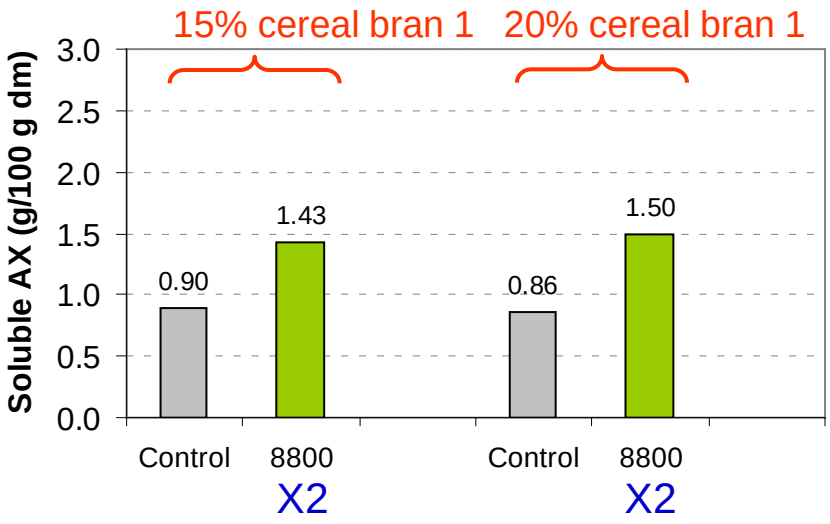
avDP sol AX = 14

AXOS content = 2.1%

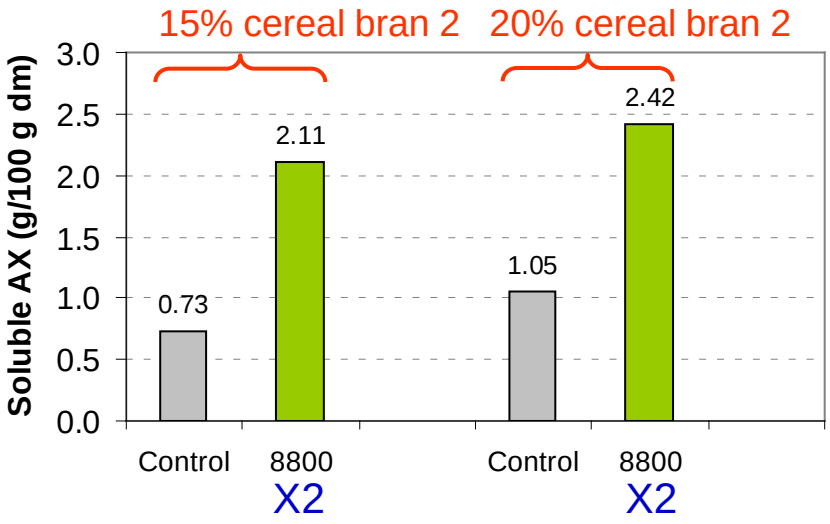
In situ AXOS production in bread

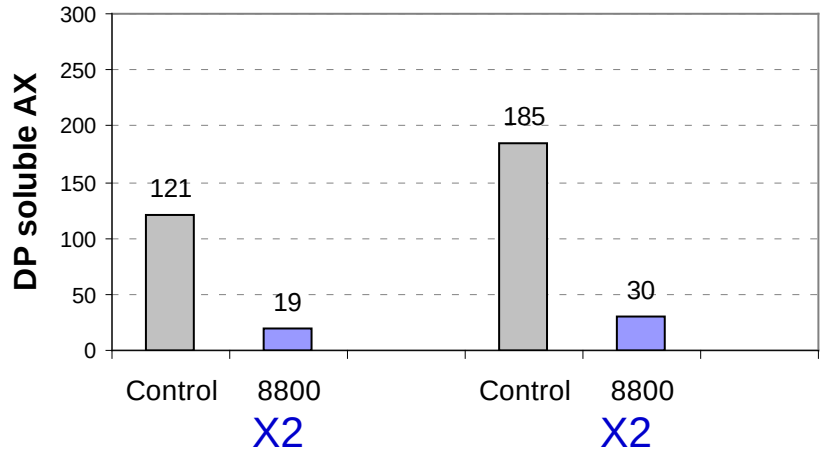
Results

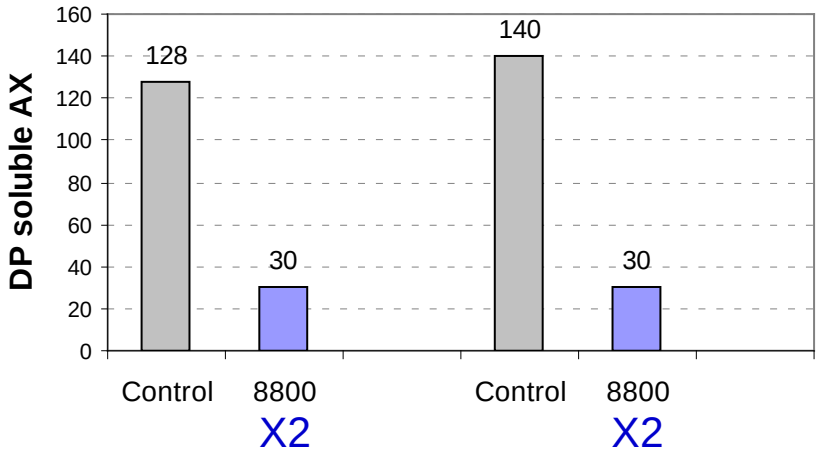
Wheat flour + Cereal bran 1



Wheat flour + Cereal bran 2



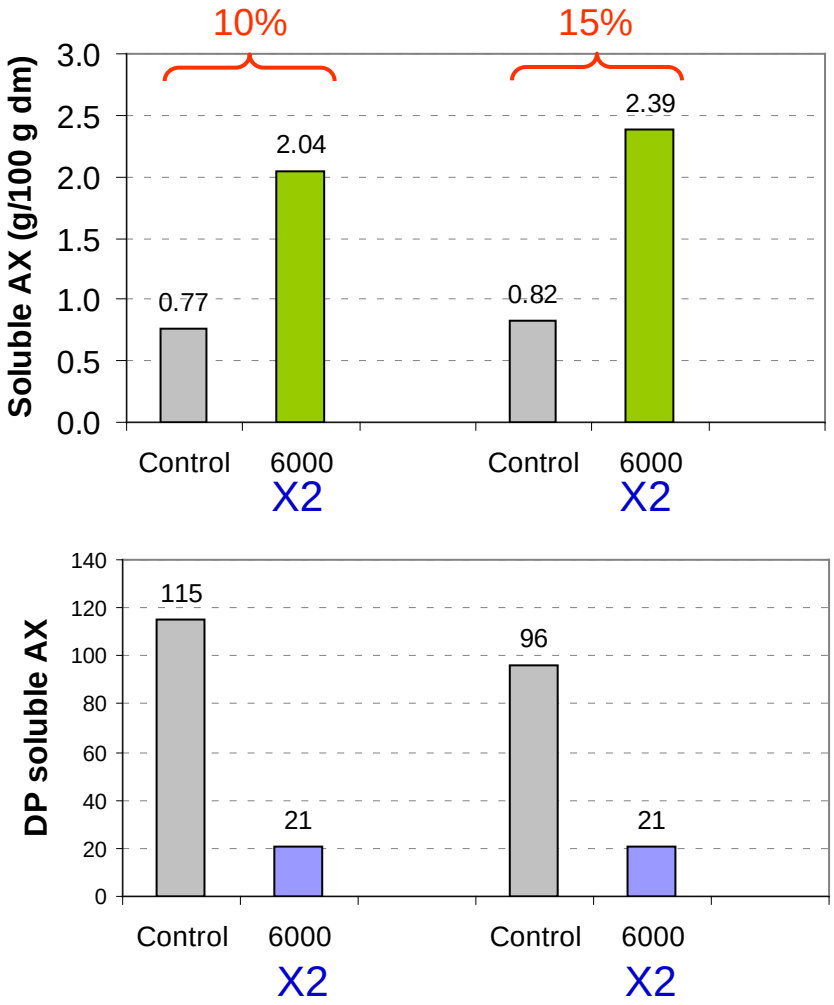




In situ AXOS production in bread

Results

Wheat flour + aleurone enriched bran fraction



Presentation overview

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General conclusions

- Using
  - 1. the right AX rich starting material and
  - 2. (thermophilic) xylanase technology

  whole meal or bran enriched AXOS products and breads with sufficiently high AXOS levels can be made, without compromising processing or end product quality

- A similar concept can be designed for HMW soluble fibre, but more evidence needed on their physiological effects

- Matching technological and nutritional needs!