Advances in technologies for gluten free products

Elke K. Arendt

Department of Food and Nutritional Sciences
University College Cork
Ireland

Coeliac Disease

What is coeliac disease?

- Autoimmune disease
- Intolerance to gluten
- Changes to the lining of the upper part of intestine
- Malabsorption

Symptoms:

Infancy (0-2 years)

Diarrhoea, Abdominal distension, Failure to thrive, Anorexia and Psychomotor impairment

Childhood

Diarrhoea or constipation

Anaemia

Loss of appetite

Adulthood

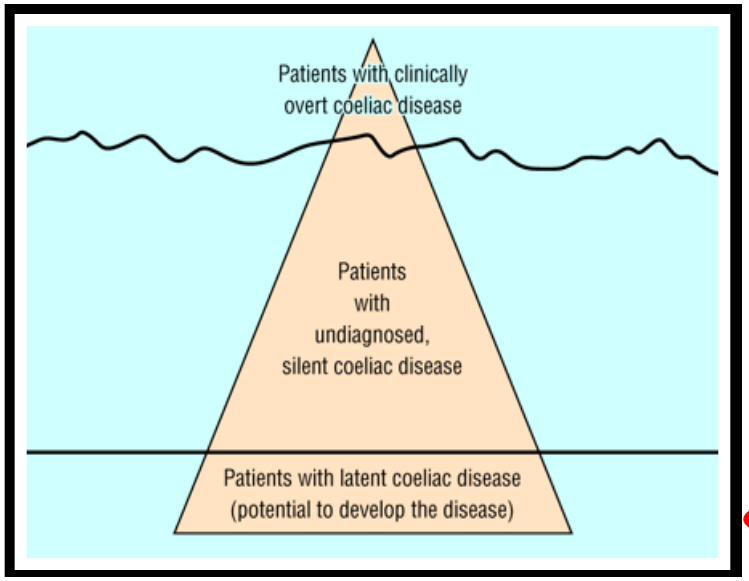
Diarrhoea or constipation

Anaemia

Aphthous ulcers, sore tongue and mouth

Epidemiology of coeliac disease

- 1 to 2 % of the world population suffers from celiac disease.
- Most common food intolerance



Iceberg model depicting prevalence of coeliac disease from Feighery (1999)

Prevalence of coeliac disease based on clinical diagnosis or screening data (from Fasano and Catassi, 2001)

Geographic area	Prevalence on clinical diagnosis	Prevalence on screening data
Denmark	1:10,000	1:500
Finland	1:1000	1:130
Germany	1:2300	1:500
Italy	1:1000	1:184
Netherlands	1:4500	1:198
Norway	1:675	1:250
Sweden	1:330	1:190
United Kingdom	1:300	1:112
United States	1:10,000	1:111
Worldwide average	1:3345	1:266

Treatment – Gluten free diet

Cereals Allowed:

GF Cereals and Pseudocereals

Oryzoidae
Rice

Panicoideae zea mays
Maize

Sorghum bicolor
Sorghum

Eragrostis tef
Teff

Eleusin coracana
Finger millet

Pennisetum glaucum
Perl Millet

Setaria Italica
Italien Millet

Fagopyrum esculentum
Buckwheat

Amaranthus cruentus
Amaranth

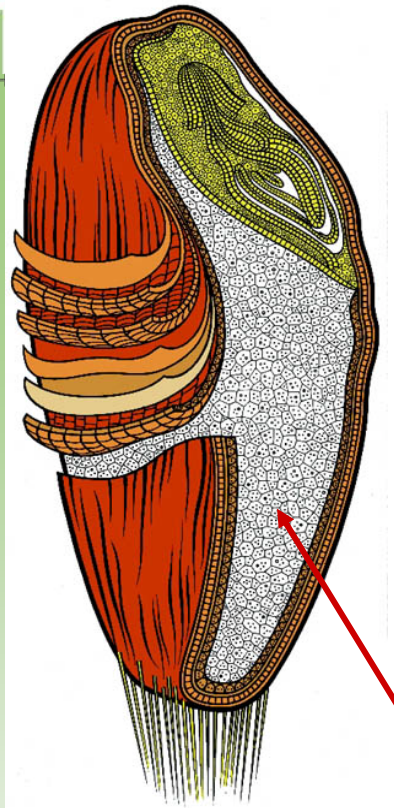
Chenopodium quinoa
Quinoa

Pseudocereals

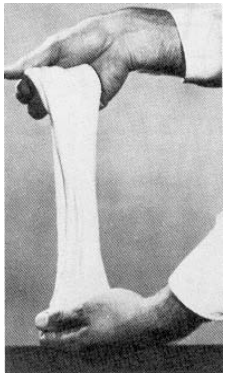
A Bite of GF Bread

- Dry, crumbly mouth feel and off-flavor
- Lacking nutrients
- Rapid staling (mostly starch based)
- Expensive

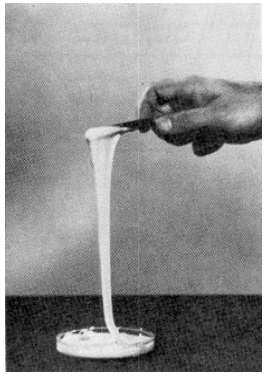
Gluten



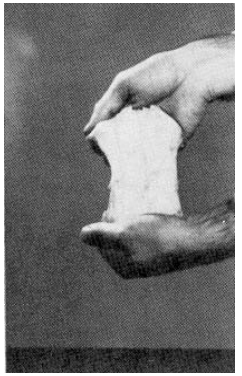
Endosperm



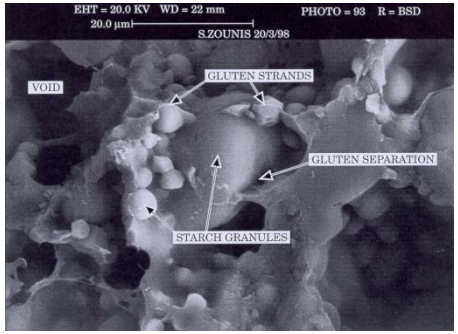
Gluten



Gliadin



Glutenin



Function

- Water-binding - helps starch gelatinisation during baking
- Visco-elastic properties – gas retention during fermentation
- Gluten associated proteases – bread flavour

Bread-making

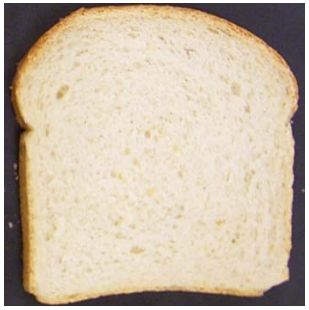
Wheat vs. Gluten-free

wheat flour + water

mixing

proofing

baking

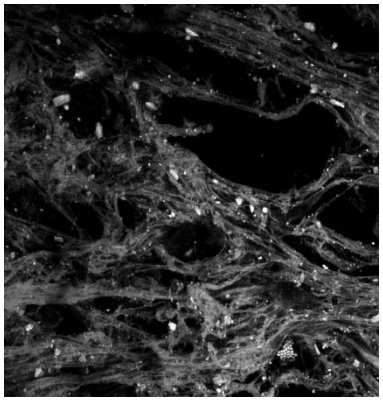


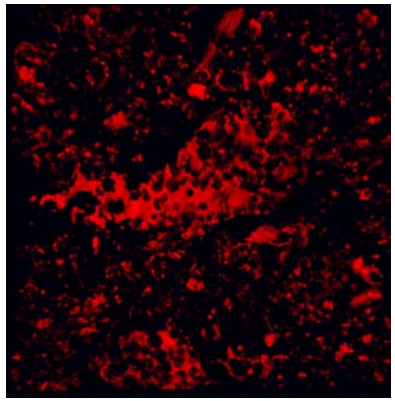
GF flour + water

mixing

proofing

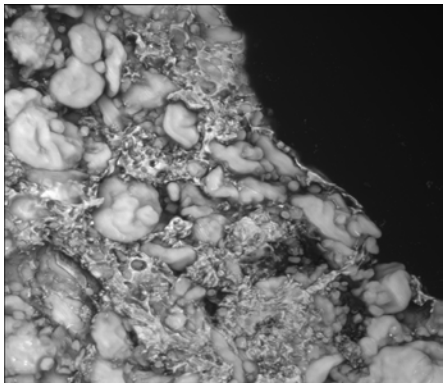
baking

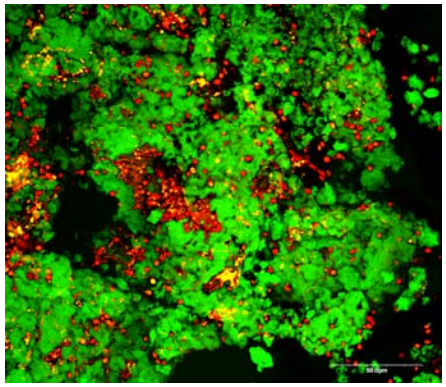




CLSM of dough/batter

CLSM of bread crumbs





An answer from the past: sourdough ?

Aroma

Organic Acids
Amino Acids (proteolysis)
Flavor (precursor) Compounds

Texture

Solubilization of Pentosans
Gluten Modification and Hydrolysis
Exopolysaccharides (EPS)

Nutritional Properties

Phytate Hydrolysis
Starch Bioavailability
Dietary Fiber (EPS)

Shelf life

Organic Acids
Antifungal compounds

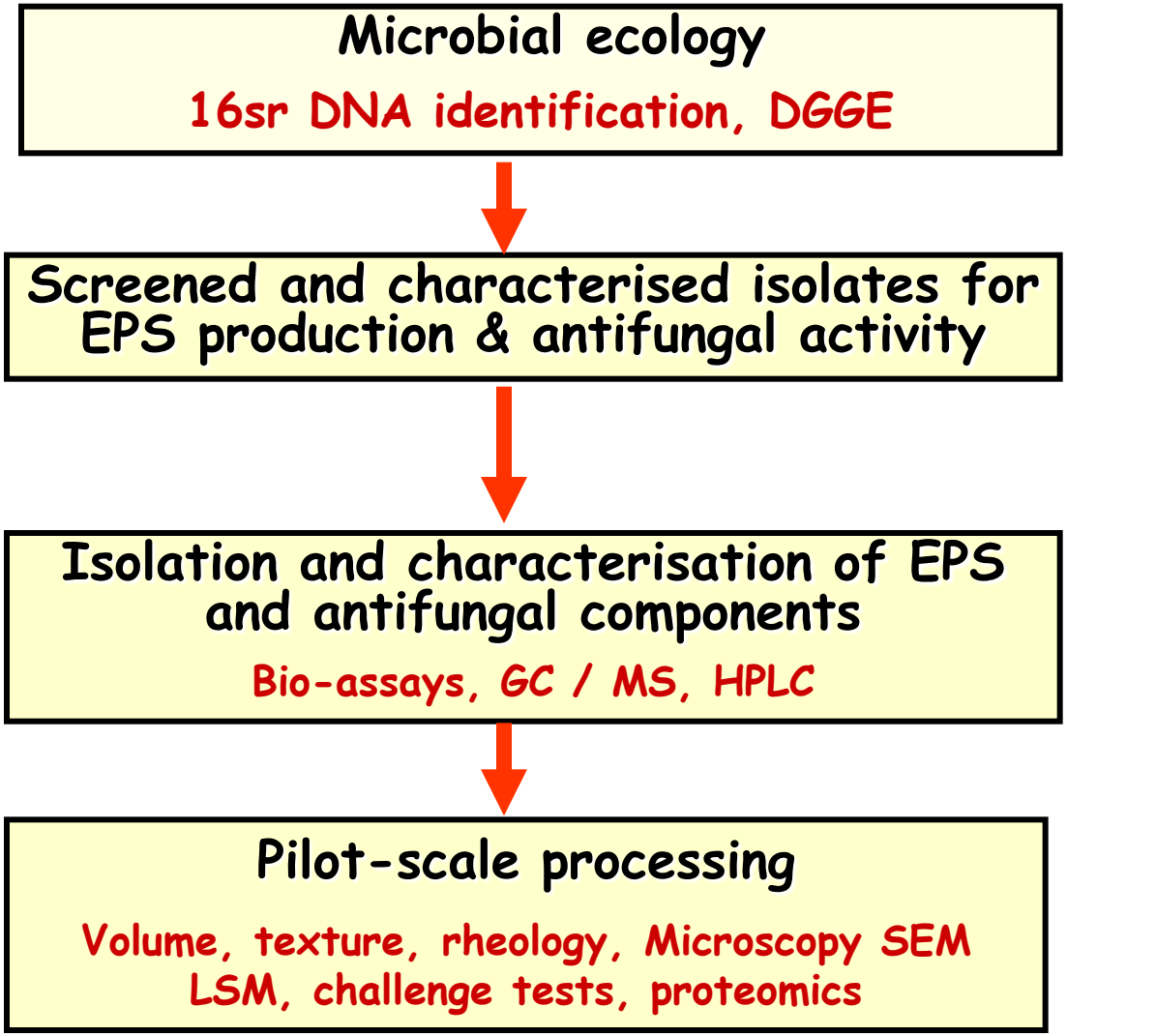
Does this apply for GF bread?

Improvement of the safety, shelf-life and texture of GF bread using Lactic acid bacteria

Antifungal

Exo-polysacchrides

Improvement of GF-bread using LAB



Shelf-life increase

Improved texture

Use of sourdough in GF baking - Conclusions

The use of sourdough in GF baking addition can lead to:

Increased Quality

Volume
Crumb texture
Softness
Reduced staling
Nutritional benefits

Higher Safety

Mould-free shelf life
Gluten removal

Lower costs

Reduced complexity of recipe
e.g. no need of hydrocolloids

… but keep in mind that …

specific sourdoughs are required for the different GF breads, and technologies have to be adapted accordingly

Enzymes and their influence on GF -bread

Screening of the effect of enzymes on gluten free cereals

Transglutaminase, Laccase, Glucose oxidase & Protease

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Characterisation the impact on rheological properties

Fundamental rheology, viscometry, creep-test, rapid visco-analyser

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Impact of bread characteristics and ultra structure

Texture profile analysis, image analysis, rheo-fermento-meter, laser scanning microscopy, electron-microscopy

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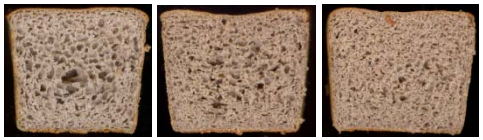
Understanding of the interactions

Capillary electrophoresis, size exclusion chromatography, NIR, HPLC, SDS, 2D electrophoresis

Transglutaminase – Different GF-Raw-material

Raw-material	Structure	Rheology
Buckwheat 	Positive	G' ↑ G'' -
Brown rice 	Positive	G' ↑ G'' -
Corn 	Positive	G' ↓ G'' ↓
Oats 	None	No changes
Teff 	None	No changes
Sorghum 	None	No changes

Enzymatic treatments - Conclusions

GF bread of higher quality can be produced by using enzymes

TGase, GO, Laccase	→	Promote protein networks
Laccase and GO	→	Promote arabinoxylan networks
Proteases	→	Improve foaming properties Reduce interference with starch gel phase (?)

… but keep in mind that …

each flour reacts differently to the various enzymes, and thus type and amount of enzyme have to be designed for the flour of interest

Oats

- Traditionally been excluded from the GF diet
- Consumer demand for healthy gluten-free (GF) products
- Growing interest in oats due to its dietary benefits
  - → Dietary fibre (in particular β-glucan)
  - → Amino acids (lysine, methionine, cysteine)
  - → Unsaturated fatty acids (linoleic acid 18:2, n-6)
  - → Vitamins (B-vitamins, vitamin E)
  - → Minerals (Mg, Zn, Fe, K)
  - → Antioxidants (e.g. avenanthramides)

- Most studied cereal in connection with CD (together with wheat)
- Recent studies have shown that oats can be tolerated by most people suffering from CD

→ Need to clarify position of oats!

Oat – in gluten free baking

Evaluation of commercial flours

Micronutrients, pilot-scale processing, rheology, proteomics, microscopy SEM,LSM

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Characterisation of oat varieties

Micronutrients, pilot-scale processing, rheology, proteomics, microscopy SEM,LSM

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Development of starter culture systems for oat

Microbiology, DGGE, pilot-scale processing, rheology, microscopy

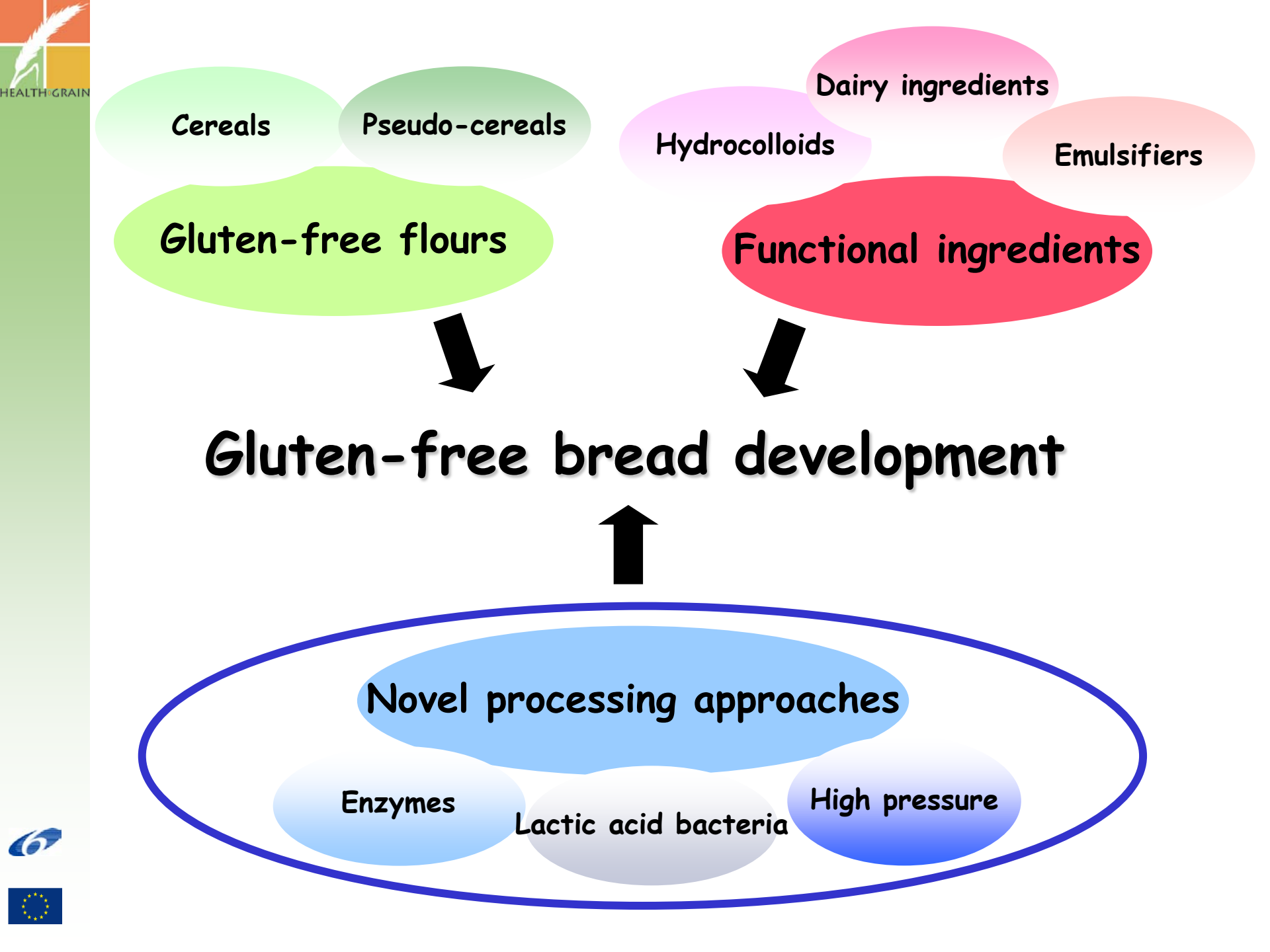
↓

Enzyme and High pressure processing

Volume, texture, rheology, Microscopy SEM LSM, challenge tests, proteomics

Conclusions – Oat

- Oat varieties differ in their bread making properties
- Most significant differences in bread quality observed for crumb structure
- Oat varieties for bread making should have
  → Protein content of about 12 %
  → High fat content
  → High final viscosity and setback
  → Low α-amylase activity (heat treatment)


Cereals
Pseudo-cereals
Dairy ingredients
Hydrocolloids
Emulsifiers
Gluten-free flours
Functional ingredients
Gluten-free bread development
Novel processing approaches
Enzymes
Lactic acid bacteria
High pressure

Conclusions

GF Cereals
rich in fibre & micro-nutrients

Pseudo-cereals

Enzymes

Starch

Water

Hydrocolloids

Protein Source or Proteolysis

Sourdough