What is behind cereal flavour: Case studies on linking sensory and instrumental data

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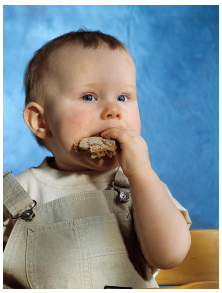
Outline of presentation

- Benefits of wholegrain products
- Formation and modification of flavour of cereal products
- Relating perceived flavour and flavour-active chemical compounds
- Case studies
  1. Stability of oats
  2. Milling fractionation of rye: Flavour and bioactivity
  3. Tailoring cereal flavour by bioprocessing
  4. Enzyme-aided flavour boosting

WHY WHOLE GRAIN?
Rye and oat are consumed as whole grain



- Raw material for health-beneficial foods
- Decreases risk to several diseases, e.g. diabetes, cardiovascular diseases and many cancers

- High fibre content, low fat content
- Good source of starch, valuable proteins, high vitamin and mineral content
- Several phytochemicals: lignans, plant sterols, alk(en)ylresorcinols (in rye), avenanthramides (in oats), phenolic acids; Most phenolic compounds bioactive & influence perceived flavour

Consumer-originated product development of cereal products

- Flavour & texture of cereal products must appeal to consumers and meet their expectations
- Desired flavour & texture to be ACTIVELY DESIGNED instead of just measuring sensory profiles of products
- Flavour & texture of cereal foods to be adjusted by DIFFERENT PROCESSING TECHNIQUES to produce ideal products

Formation and modification of flavour of cereal products

- Flavour of native grain is rather mild and bland
- Grain must be processed prior to use in human consumption
- Cereal flavour forms in processing

5 RLH

Flavour formation in cereal products

What is 'cereal-like' flavour?

- Rye-like flavour = Flavour of rye bread ?
- Oat-like flavour = Flavour of oat porridge ?

All cereal have their characteristic flavour

- Oat flavour different from rye flavour

Variety of grain, season and cultivation area influence flavour

- Oat cultivar Veli has sweeter, more oat-like flavour than cv. Lisbeth

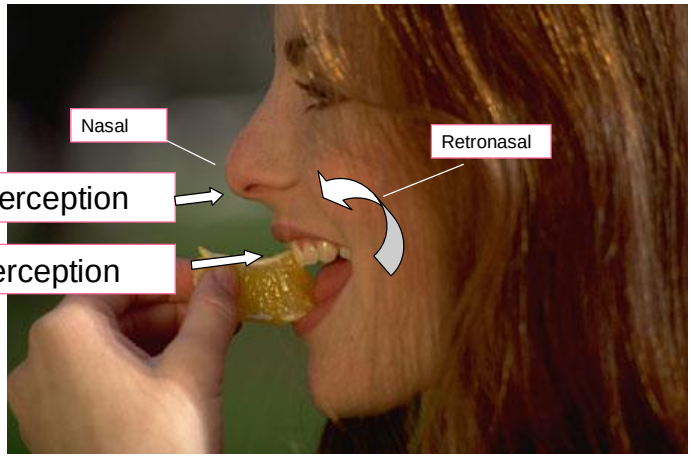
6 RLH

Tailoring desired flavour & texture to cereal products

- Mechanical milling fractionation of the grain
- Sourdough fermentation & baking
- Germination (malting) & drying
- Heat treatment: Extrusion, puffing in autoclave, IR-roasting …
- Enzymatic flavour-boosting

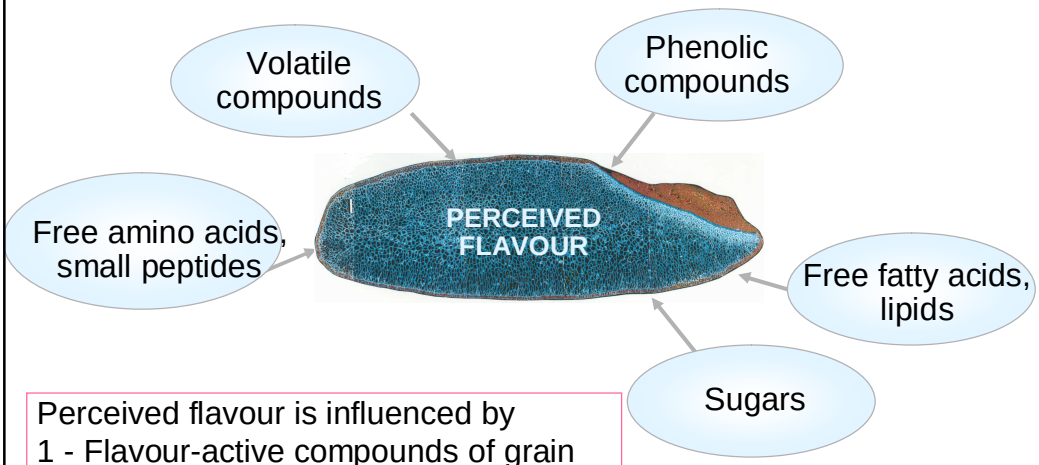
•Fermentation & germination increase amounts of health-beneficial phenolic compounds, concurrently influencing considerably perceived flavour
•Heat-treatment important step for tailoring perceived flavour (Maillard reaction)

Perception of flavour (odour & taste; mouthfeel)



Chemistry behind flavour formation

Components influencing the perceived flavour



Perceived flavour is influenced by
1 - Flavour-active compounds of grain
aldehydes, alcohols, ketones, phenolic compounds
2 - Flavour precursors in grain
amino acids, sugars, fatty acids, phenolic compounds

In addition to volatile compounds, several non-volatile components affect the perceived flavour

Flavour-active compounds influence perceived flavour of a product, but…

• Specific odour/ taste thresholds of the chemical compounds

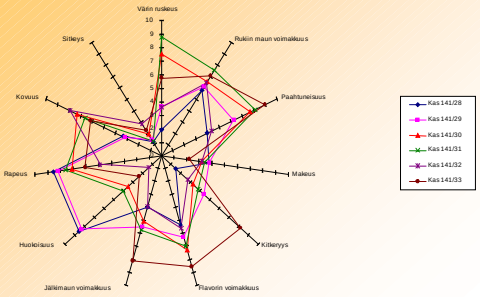
All chemical compounds are not responsible for flavour sensation

•Synergistic or suppressive effects of compounds

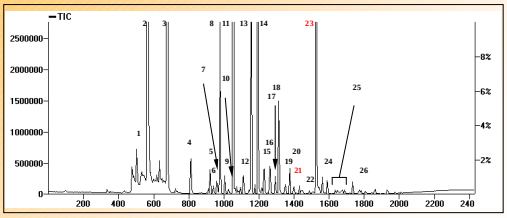
• Individual differences in sensitivity of odour/ flavour perception

PLS regression - Relating perceived flavour and flavour-active chemical compounds by multivariate statistics

Sensory assessment by descriptive profiling

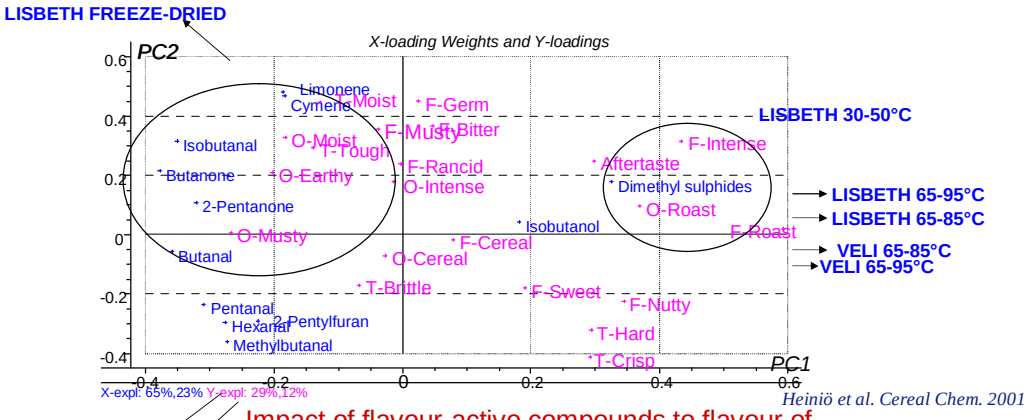


GC/MS quantification of e.g. volatile compounds



PLS regression - Relating perceived flavour and flavour-active chemical compounds by multivariate statistics

Perceived flavour and volatile compounds analysed separately

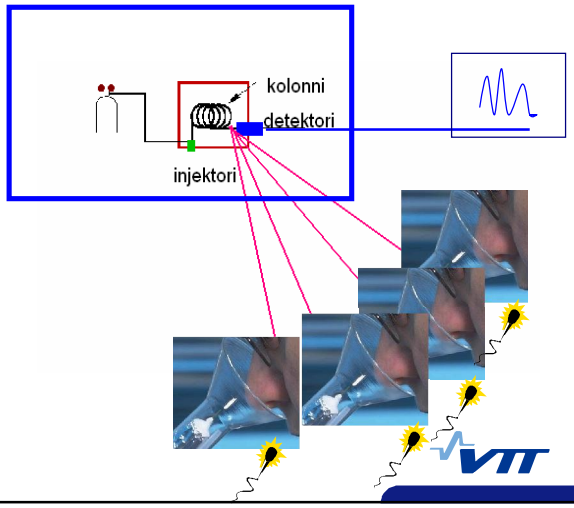


Heiniö et al. Cereal Chem. 2001

Impact of flavour-active compounds to flavour of germinated, heat-treated oat: Roasted, nutty, sweet flavour, crisp texture results when drying at 85°C

GC-Olfactometry

GC analysis combined with simultaneous odour perception



GC-Olfactometry

Flavour extraction by SPME (compound-specific fibres)

10.6		(sweet)
10.8	hexanal	
11	3-methyl-2-pentanol, ethyl lactate	sweet, clover, green (fruit)
11.2	dihydro-2-methyl-3(2H)-furanone	
11.4	tetrachloroetene	(solvent)
11.6		
11.8	methylpyrazine	
12	furfural	
12.2		
12.4	furan methanol	
12.6	hexanol	sweet, vomit, pungent, rancid
12.8		sweet, vomit, pungent, rancid
13		sweet, vomit, pungent, rancid
13.2	2-heptanone	sweet, vomit, pungent, rancid
13.4		
13.6	heptanal	

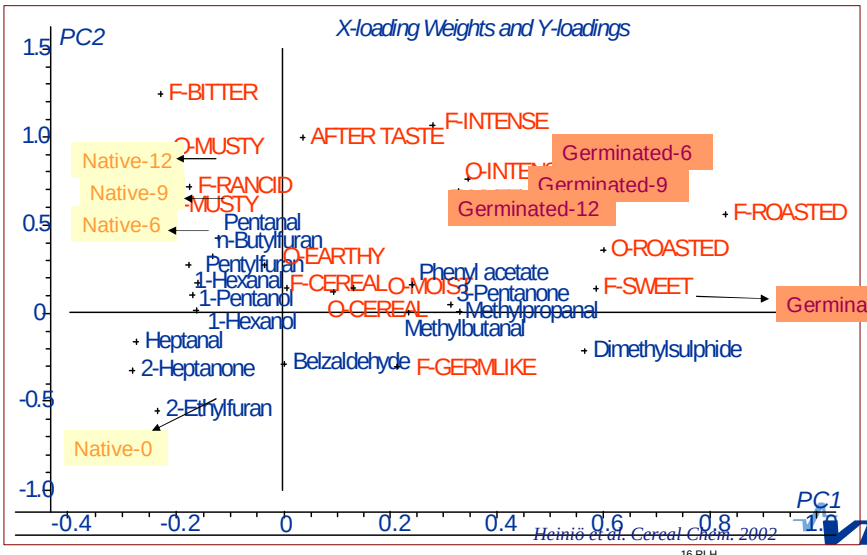
Piece of GC-Olfactometry chromatogram of a cereal product

14 RLH

CASE 1 - Stability of oat

- Rancid and bitter flavour develops easily in oat during storage due to its high fat content
- Germination-drying process can be used to adjust effectively the perceived flavour and to increase the flavour stability

CASE 1 - Relating perceived flavour and flavour-active volatile compounds of stored oat



Heiniö et al. Cereal Chem. 2002

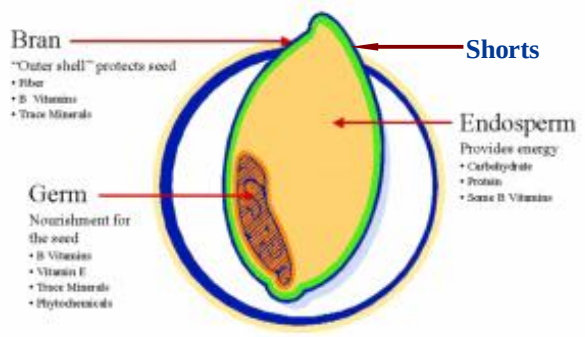
16 RLH

CASE 1 - Stability of oat

- Musty, earthy odour and bitter, rancid flavour in stored, deteriorated oat; these attributes closely correlate with free fatty acids and volatile compounds related to lipid oxidation
- However, phenolic compounds and volatile compounds derived from protein degradation are related to favourable roasted flavour

CASE 2 - Milling fractionation of rye: Flavour and bioactivity

- In mechanical milling fractionation rye kernel is separated into fractions, each of them having their characteristic flavour



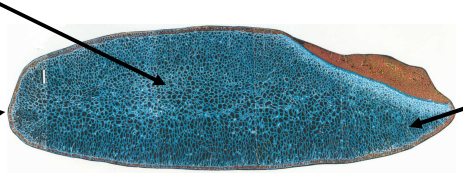
CASE 2 - Flavour of milling fractionationated rye grain

Flavour components unevenly distributed to different layers of rye grain

Endosperm: Mild flavour

Shorts: Rye-like flavour without bitterness

Bran: Strong, bitter flavour

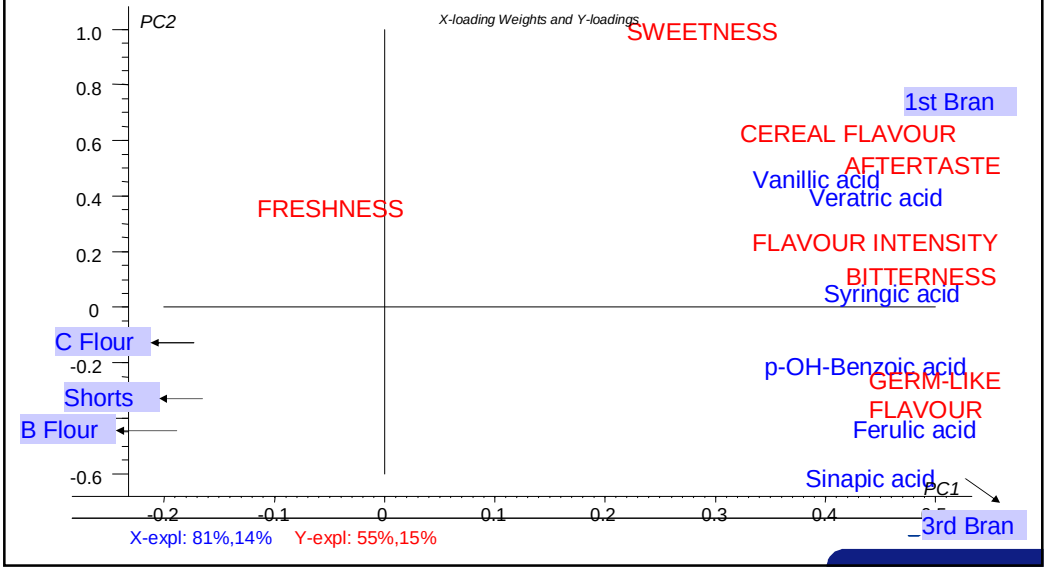


Between mild-tasting innermost part and bitter-tasting outer bran fraction, rye-like flavour without bitterness is observed

This shorts fraction contains significant amounts of health-beneficial, nonvolatile phenolic compounds (phenolic acids, alk(en)ylresorcinols and lignans), which may have input to perceived flavour

Heiniö R-L *et al. LWT* 2003a

CASE 2 - Flavour and bioactivity of fractionationated rye: Flavour vs. Free phenolic acids



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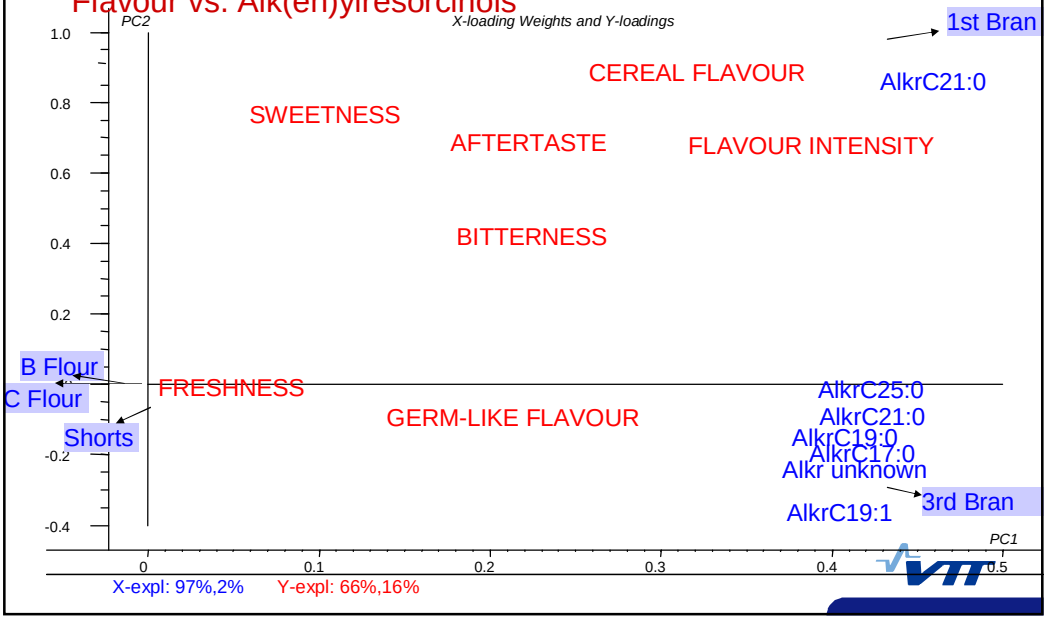
CASE 2 - Flavour and bioactivity of fractionationated rye: Flavour vs. Alk(en)ylresorcinols



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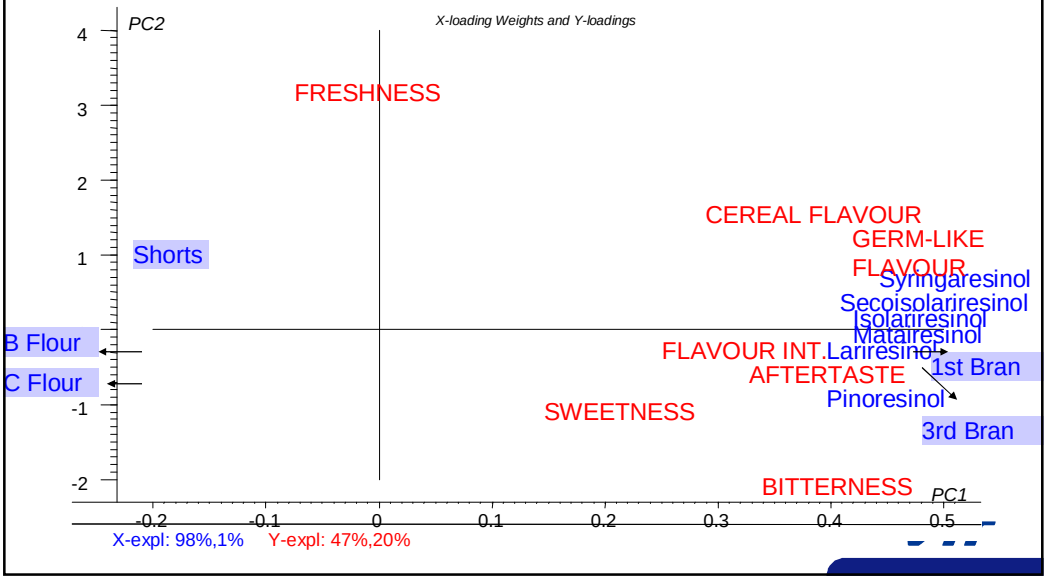
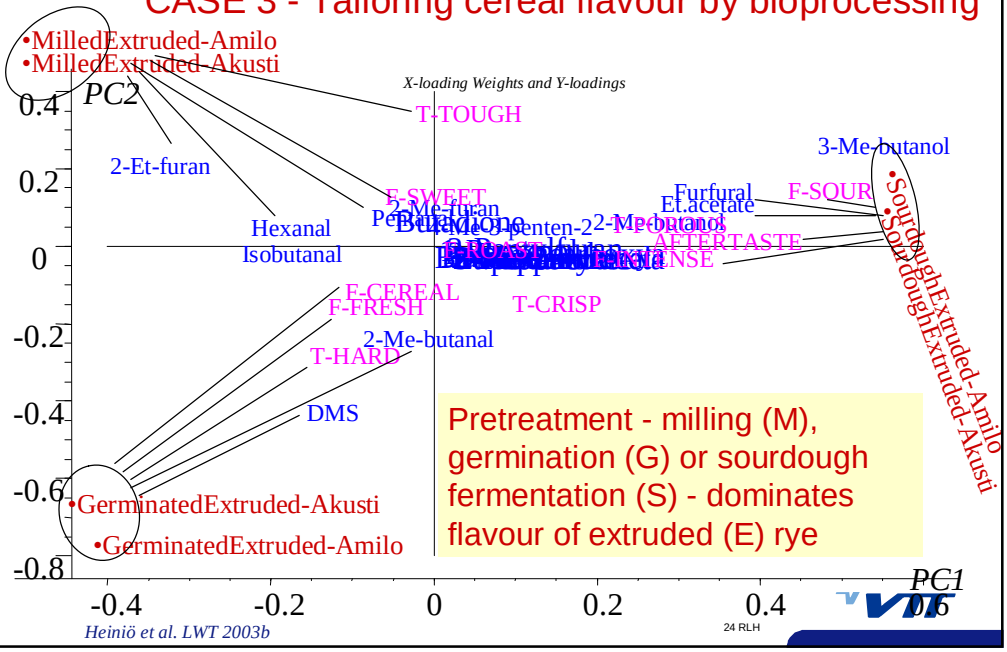
CASE 2 - Flavour and bioactivity of fractionationated rye: Flavour vs. Lignans



CASE 3 - Tailoring cereal flavour by bioprocessing

- Different volatile compounds evaporate from same raw material depending on the applied bioprocessing technique
- Thus, sourdough fermented, germinated and milled rye extrudates deviate from each other both in their sensory attributes and their volatile compounds

CASE 3 - Tailoring cereal flavour by bioprocessing



Pretreatment - milling (M), germination (G) or sourdough fermentation (S) - dominates flavour of extruded (E) rye

Heiniö et al. LWT 2003b

24 RLH

CASE 4 - Enzyme-aided flavour boosting

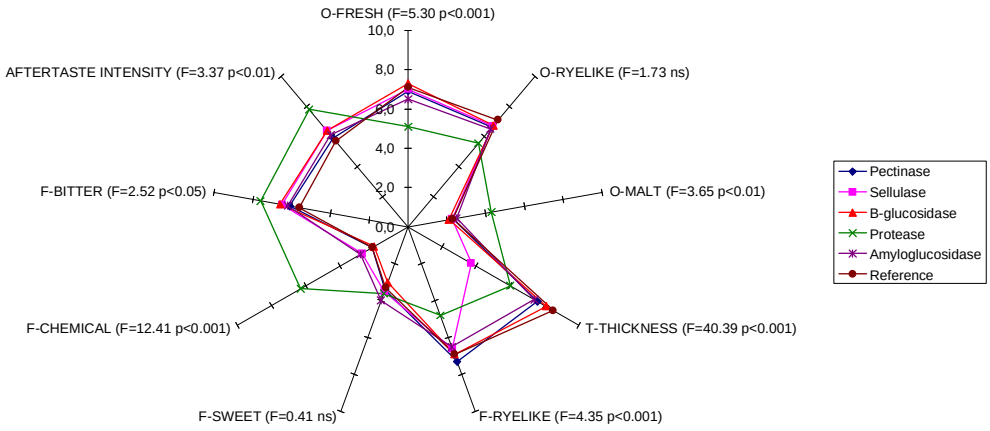
- Enzymatic treatment is a new approach for modifying flavour
- Intensive, bitter flavour of rye may be caused by small peptides and phenolic compounds, and can be studied by enzyme-aided processing
- Bitterness could be blocked by

  A - Breakdown/ polymerisation of compounds influencing harmfully on flavour

  B - Formation of flavour-beneficial flavour precursors, e.g. for Maillard reaction

Sensory assessment of enzyme-boosted rye

Sensory profiles of rye-water suspensions with high enzyme dosages (n=2 x 9)



Most intense bitterness in rye-water suspensions caused by protease

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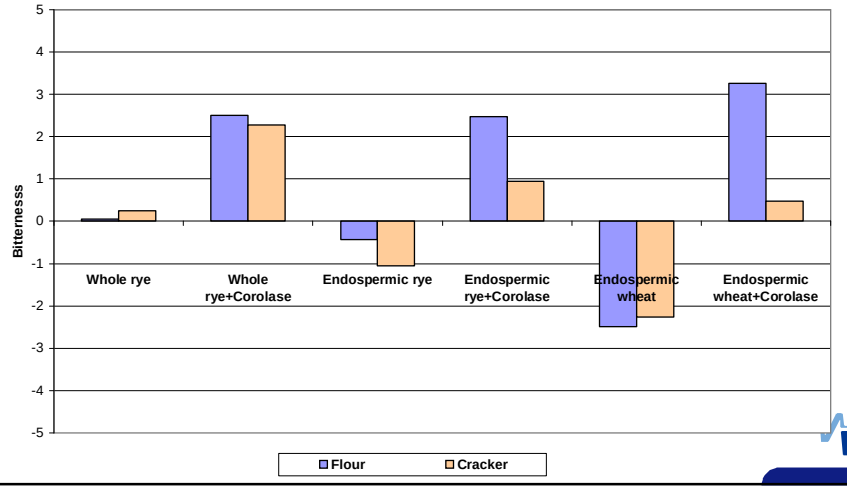
CASE 4 - Enzyme-aided flavour boosting
Perceived bitterness

Bitterness of flour and cracker after Corolase additions (n=2 x 9-10)



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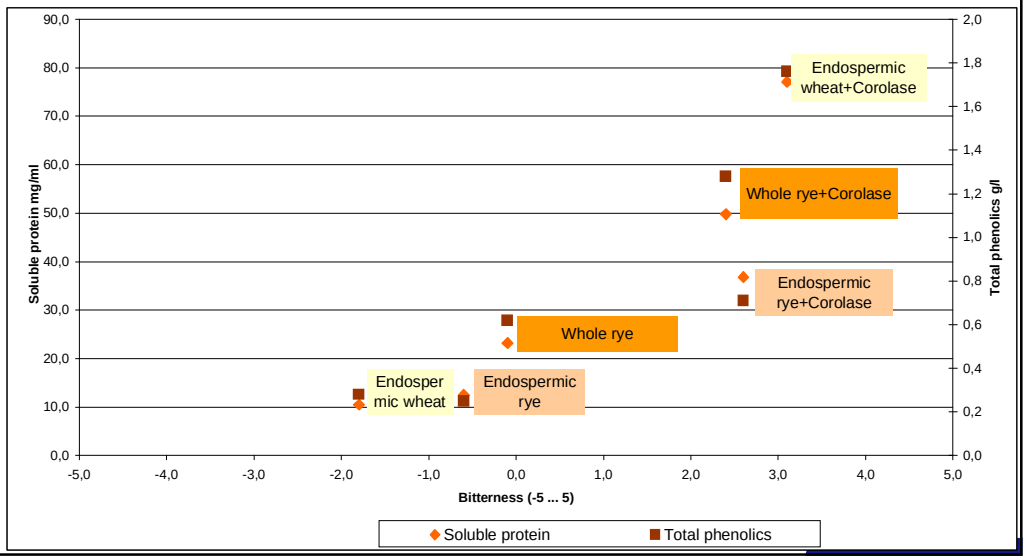
CASE 4 - Enzyme-aided flavour boosting
Bitterness, soluble proteins and total phenolics



Conclusions

- Cereal flavour influenced by volatile and phenolic compounds, amino acids, sugars and fatty acids
- Tools for relating perceived flavour and flavous-active chemical compounds: PLS regression & GC-olfactometry
- Flavour of native grain is mild -> Processing required: milling fractionation,sourdough fermentation & baking, germination, heat and enzymatic treatments

New tools for developing novel, palatable, health-beneficial breakfast & snack applications from cereal