

Novel dry fractionation technologies

Dry fractionation of wheat bran for the manufacture of healthy food ingredients

Xavier ROUAU¹,

Nuria MATEO-ANSON², Cécile BARRON¹, Marc CHAURAND¹,

Valérie LULLIEN-PELLERIN¹, Frédéric MABILLE¹, Marie-Françoise SAMSON¹,

Joel ABECASSIS¹, Rob HAVENAAR² and Youna HEMERY¹



1. INRA, UMR Ingénierie des Agropolymères et Technologies Emergentes
CIRAD-INRA-SupAgro-Université Montpellier 2, France.



2. TNO, Department of Physiological Sciences, Zeist, The Netherlands.

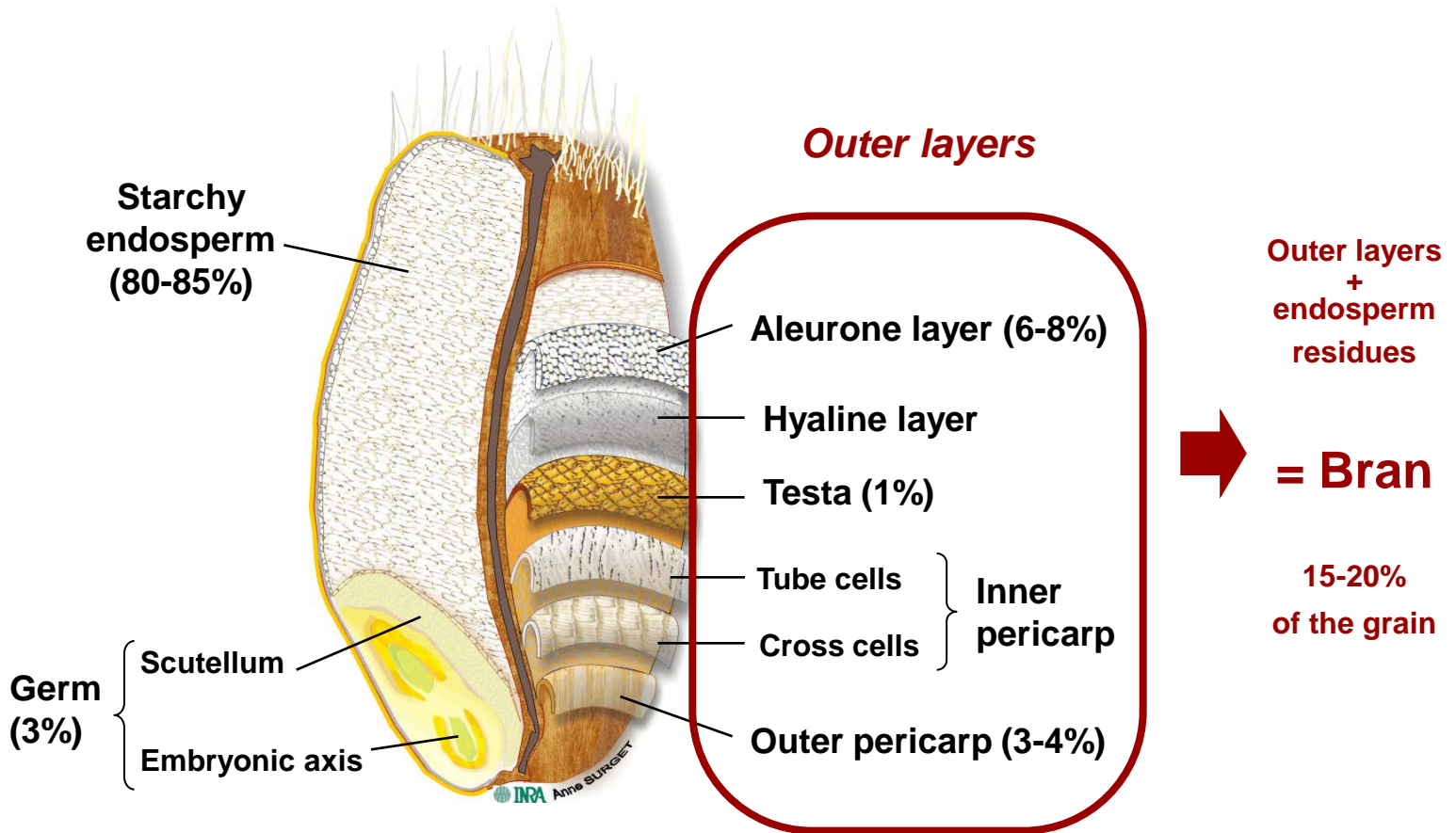


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Wheat grain

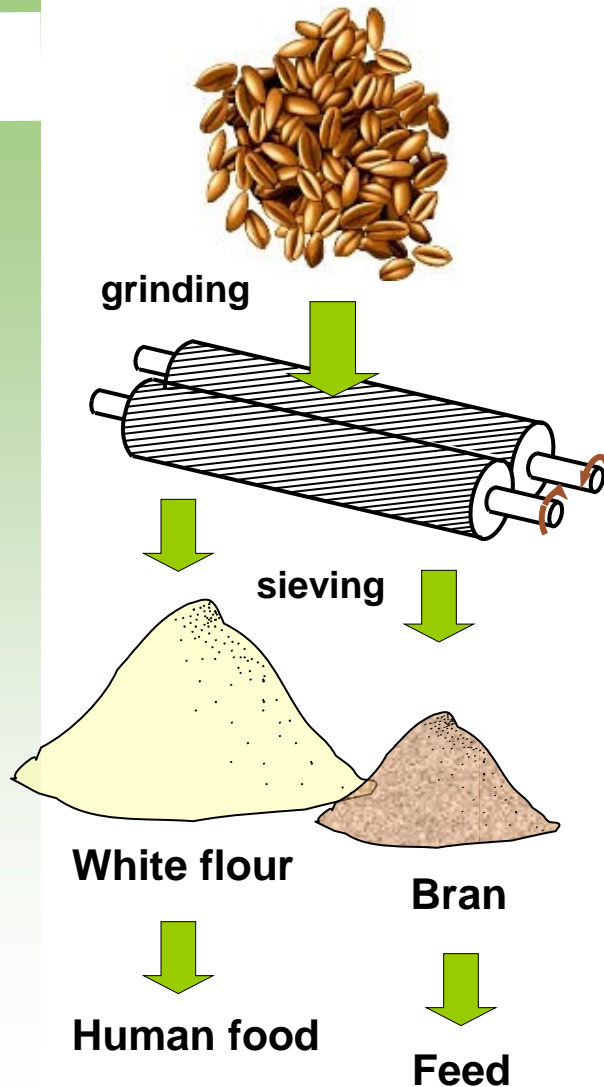
complex structure, composed of several parts :



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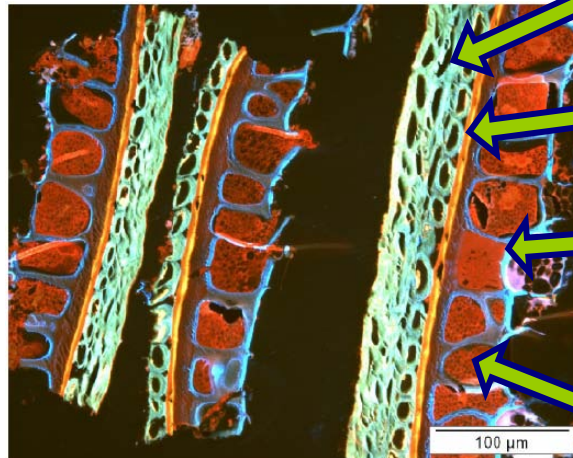
Wheat bran important by-product :

- 6 million tons produced / year in Europe
- Under-valued, mostly used for animal feed
- But interesting nutritional potential !!!



Novel dry fractionation technologies**"Enhancing health benefits of cereal foods -
results, perspectives and challenges"****Wheat bran :**

- Multi-layered **composite material** (Pericarp / Testa / Hyaline / Aleurone).
- Contains most of the vitamins, minerals, antioxidants & interesting phytochemicals.

*Microscopy analyses : VTT-Finland*

Pericarp : {

- Insoluble dietary fibers
- Antioxidants bound to cell walls (phenolic acids)

Testa : *Alkylresorcinols*

Aleurone cell wall: {

- Dietary fibers (arabinoxylans, β -glucans)
- Bound antioxidants (phenolic acids)

Intracellular contents (trapped in the cells): {

- Proteins & lipids
- Antioxidants (phenolic acids)
- E & B vitamins
- Minerals + Phytic acid

Can contribute to increase the nutritional quality of foods, if included in flours during milling, or **used as food ingredients**.

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2010**Fractionation of wheat bran : why ?****To remove detrimental compounds**

- Microbes, mycotoxins, heavy metals & pesticide residues, concentrated in the outer pericarp
- Phenolic compounds responsible for bitter taste of whole grain
- Anti-nutritional factors like phytates, or other aleurone intracellular compounds that are detrimental for breadmaking (enzymes, thiols...)

To concentrate interesting compounds

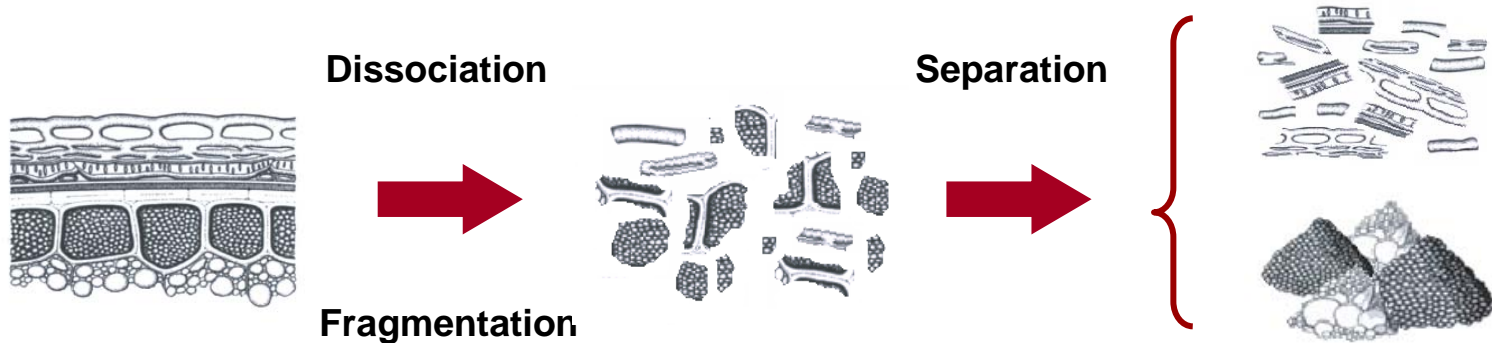
- To produce ingredients enriched in aleurone, known for its high nutritional potential
- Or ingredients rich in dietary fibres and/or rich in antioxidant compounds.

**→ To be used as "health-promoting"
food ingredients**

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Fractionation :



Combination of several processing steps :

dissociation steps + separation steps

Dry-fractionation :

- “green technology” : no harmful solvents, no effluents
- less energy consumption (no drying steps) than wet fractionation

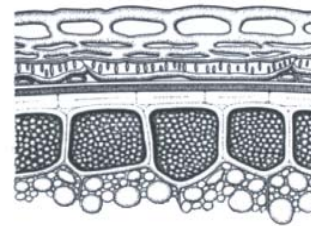


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Bran cracking for ingredient production



Histological fractionation

Sub-cellular fractionation

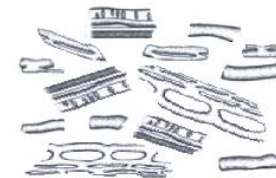
Pericarp

Testa

Aleurone

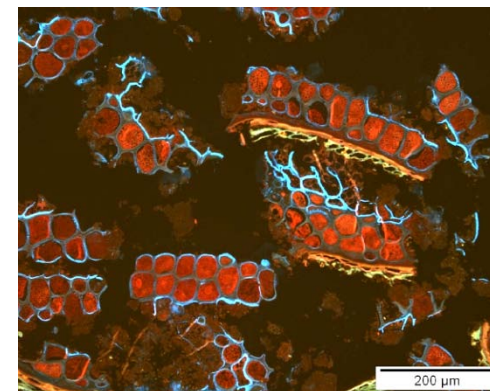
Fibres / cell walls

Cell
contents



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2010**Several processes already exist (patents) : tissue-scale**

- Stone & Minifie (1988) : separation of aleurone
- Goodman Fielder (1995) : aleurone rich flour
- Bühler (2003) : separation of aleurone cells
→ clusters of \pm intact cells

**Is it possible to fractionate more ?****from « histological fractionation » to « macro-molecular fractionation »**

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2010**Fractionation after Ultrafine Grinding (sub-cellular)**

- To identify the physical, chemical and structural characteristics that control the fragmentation, dissociation, and separation of the different bran tissues, during ultrafine grinding and separation.
- To use this information to develop bran fractionation processes at pilot scale, to produce bran fractions (food ingredients).
- To evaluate the nutritional quality of these bran fractions obtained by ultrafine grinding & electrostatic separation.



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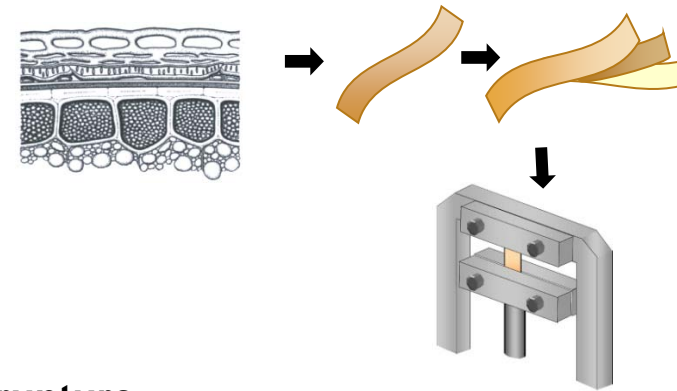
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Mechanical properties of whole bran layers

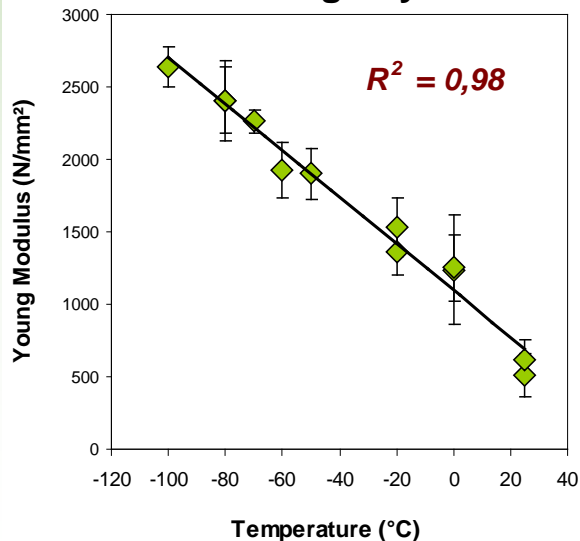
Tensile tests at controlled T

↘ T : greatly influences the mechanical properties of bran layers

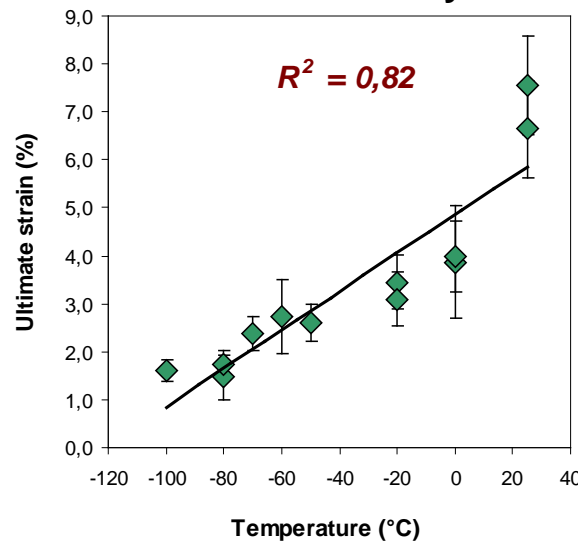
- Loss of plasticity (ductile → brittle)
- Increase in rigidity
- Decrease in extensibility & mechanical energy to rupture.



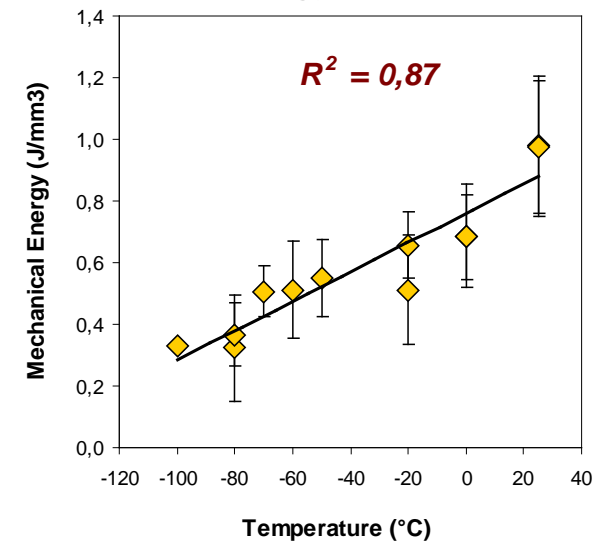
↗ Rigidity



↘ Extensibility

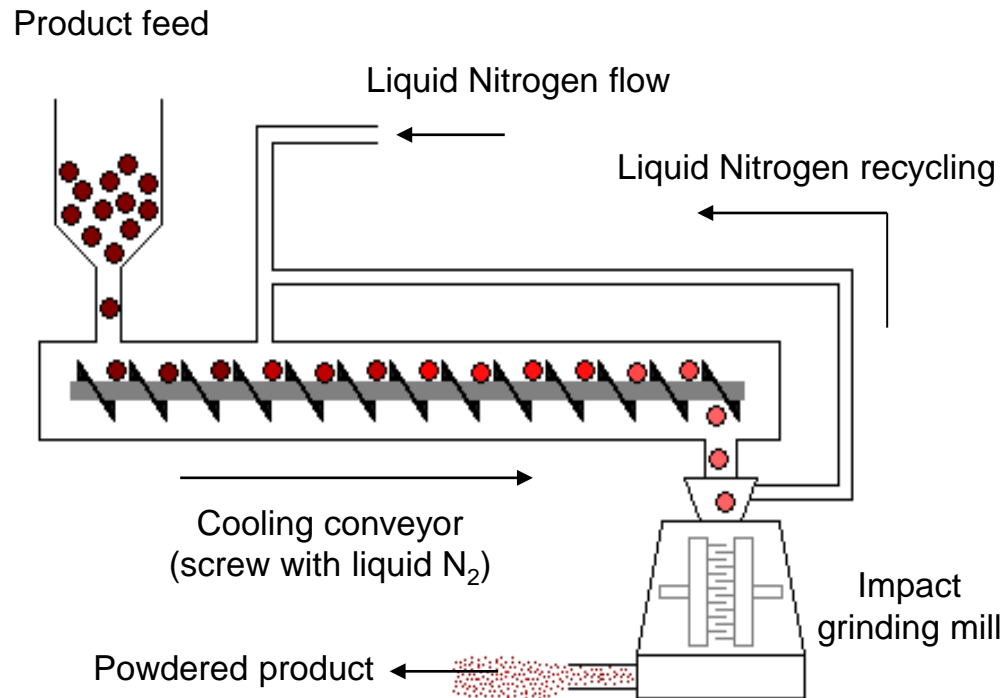


↘ Energy to rupture



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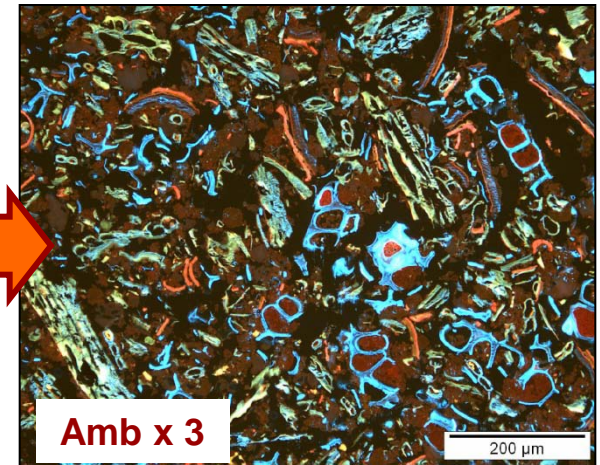
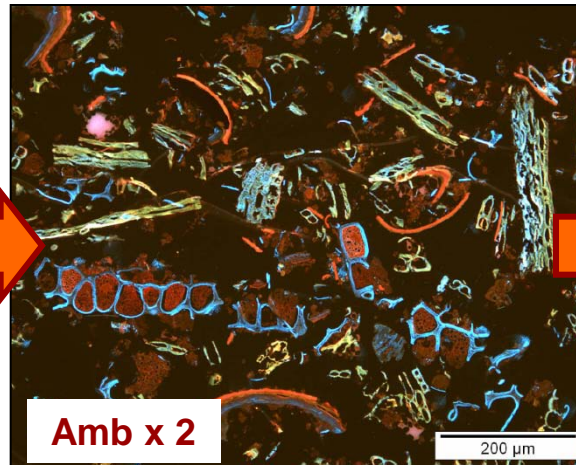
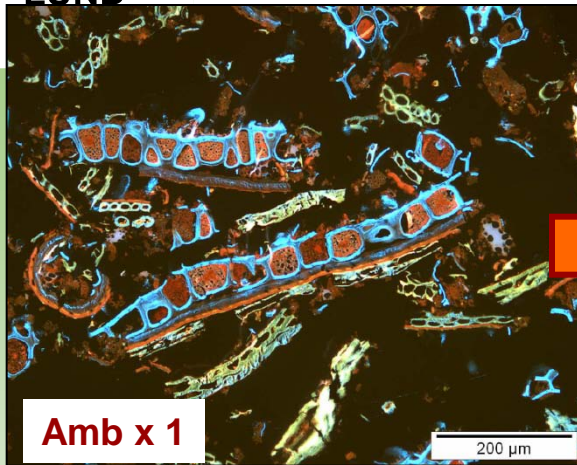
- At pilot scale : on several kg
- Grinding at ambient temperature and under cryogenic conditions (liquid nitrogen).



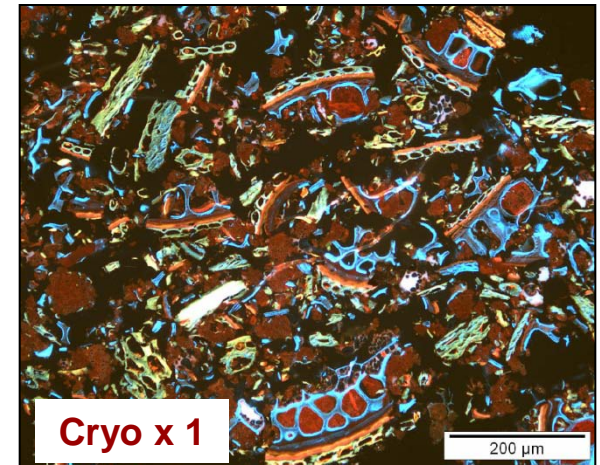
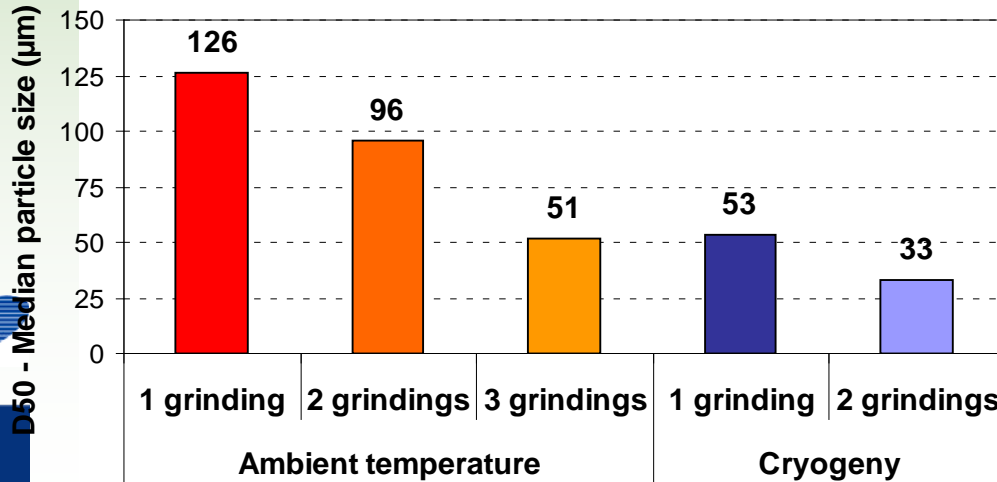
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Ultrafine grinding at 25 C (Amb) and < -50 C (Cryo)

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Pictures : *Ulla Holopainen, VTT Technical Research Centre of Finland*



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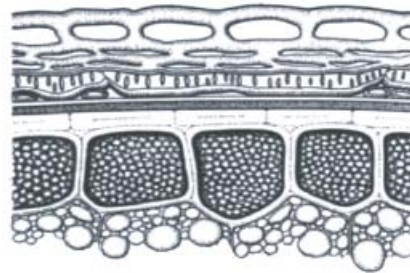
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Fragmentation & dissociation of bran layers

- The material's physical properties & its behavior during processing are related
- Influence of T & bran tissues composition on fragmentation & dissociation / grinding.

More dissociation

25 C



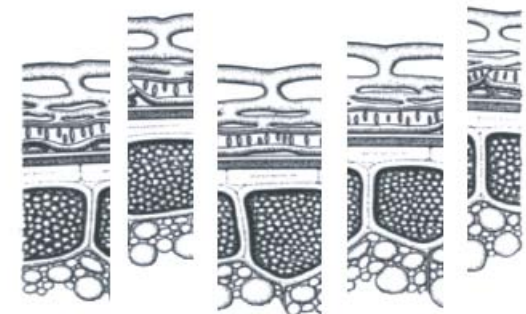
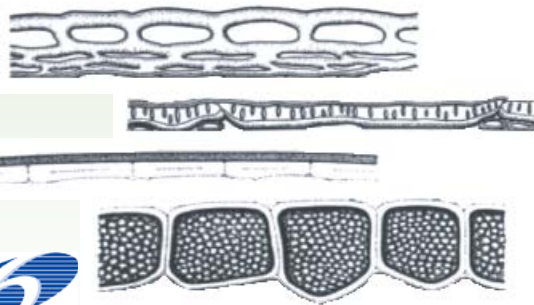
More fragmentation

< -50 C

Combination of
ambient + cryogenic
grindings



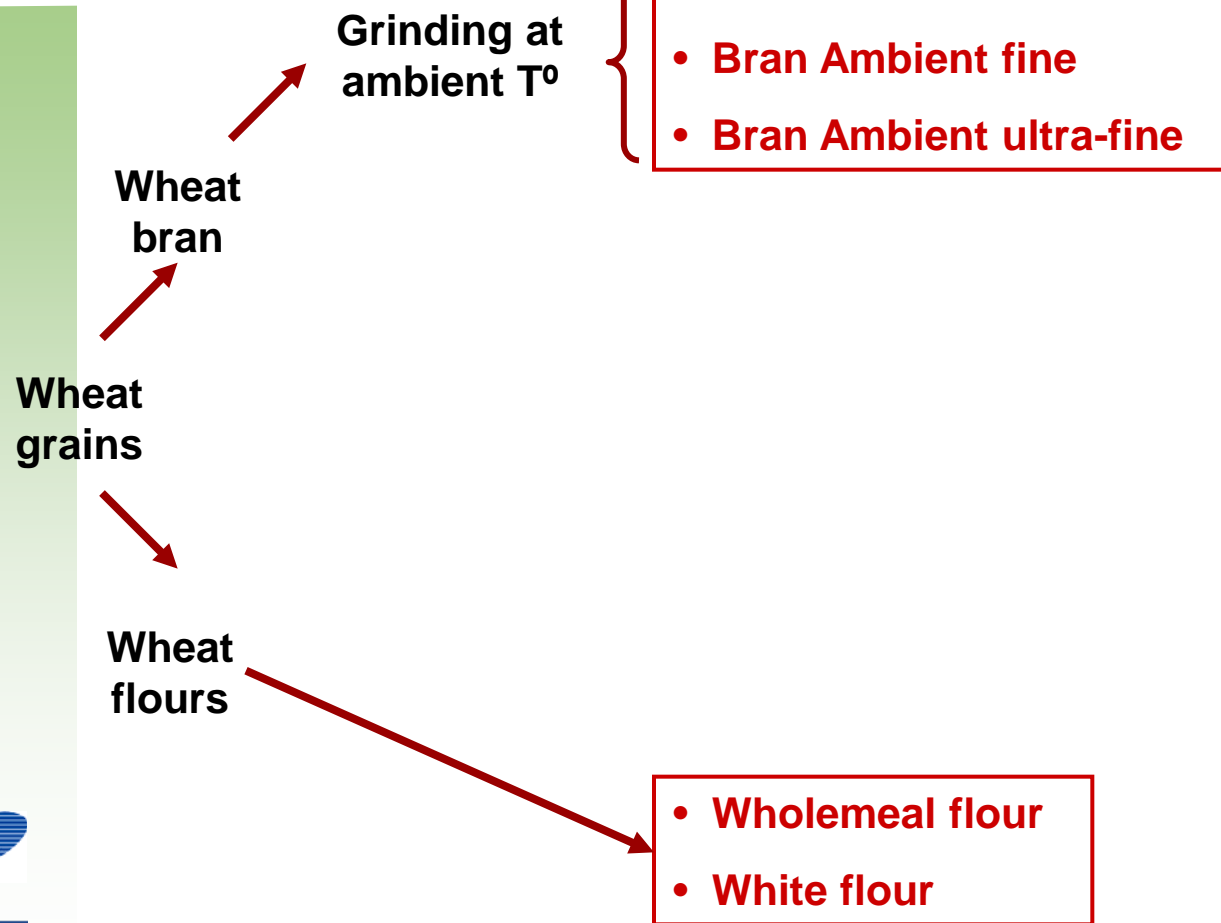
dissociation
+ fragmentation



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Effect of grinding : Production of wheat fractions & breads



*Breadmaking : M. NOORT
TNO, the Netherlands*

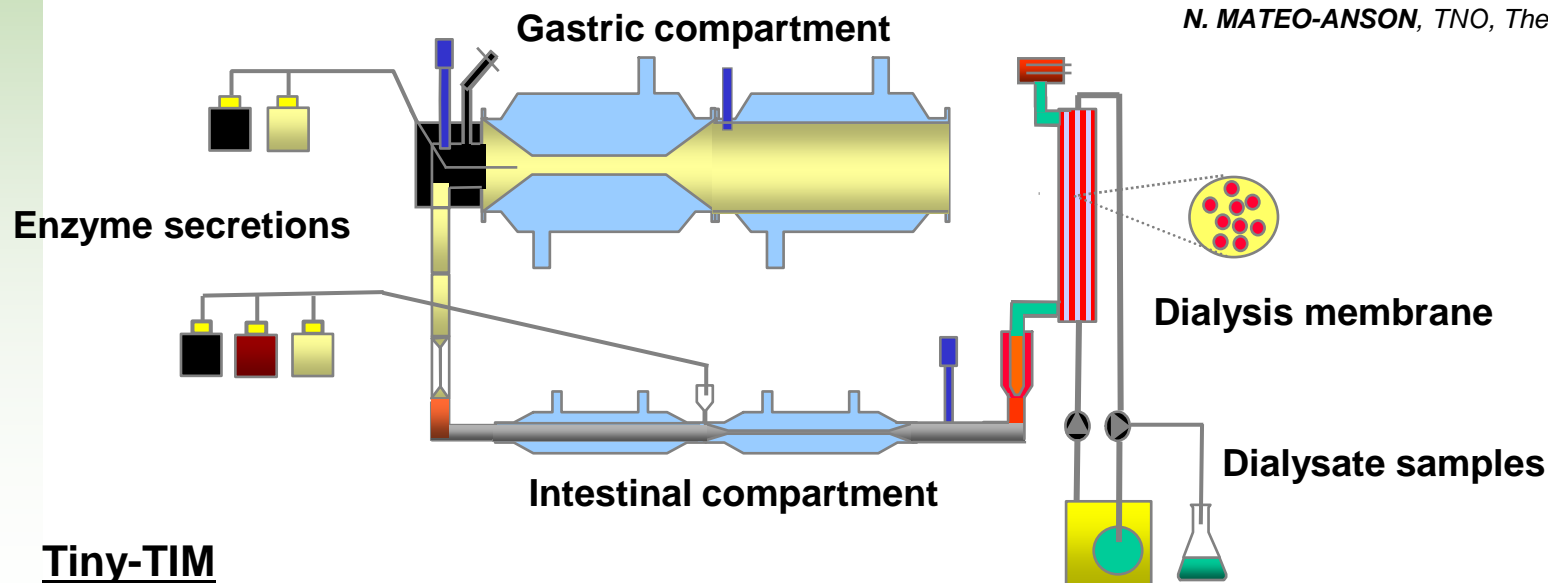
- white bread
- whole bread

- bran breads
= whole breads, same ferulic acid and ash content



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2010**Nutritional potential of bran fractions : *in vitro* digestions**

- 30g of fresh bread → Tiny-TIM digestion (TNO Intestinal Model), during 6 hours.
- Stomach + small intestine compartments.
- Controlled pH, T⁰, enzyme secretions & peristaltic movements.
- Dialysate samples (= contain all the bioaccessible compounds) collected every hour.
- Phenolic acids quantification + minerals (Mg, Zn) quantification.



In vitro digestions : **R. HAVENAAR,**
N. MATEO-ANSON, TNO, The Netherlands

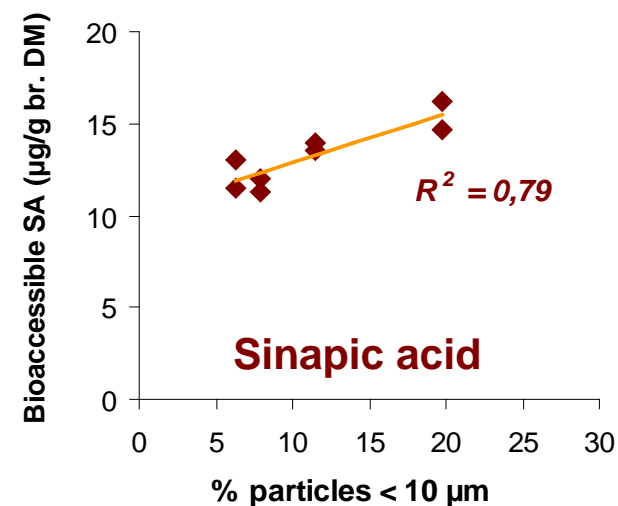
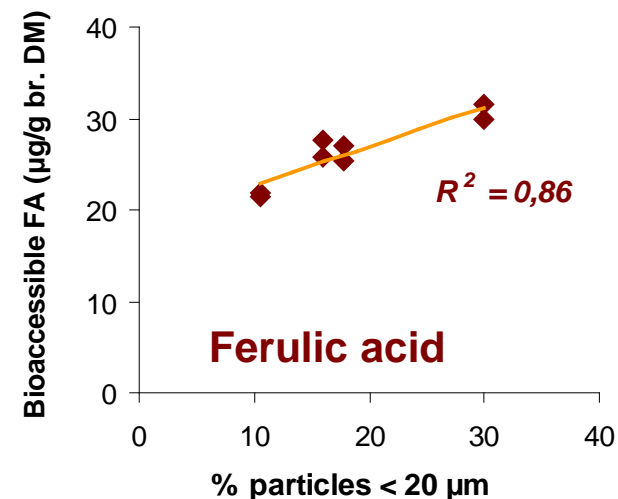
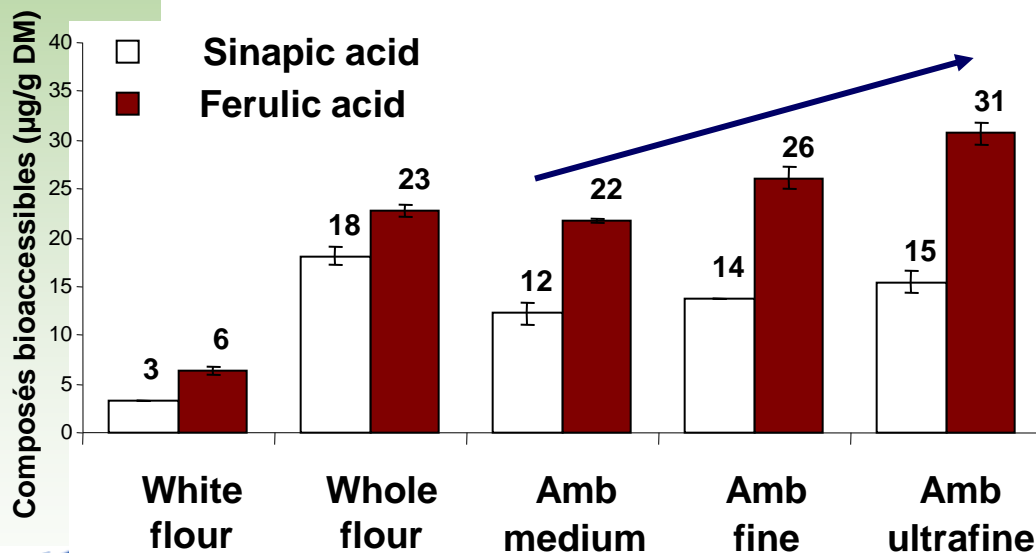
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Phenolic acid bio-accessibility

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- Sinapic and ferulic acids in aleurone cells
- \searrow particle size = \nearrow surface extractibility during digestion \Rightarrow \nearrow phenolic acid bioaccessibility
- Improvement nutrition quality of bread



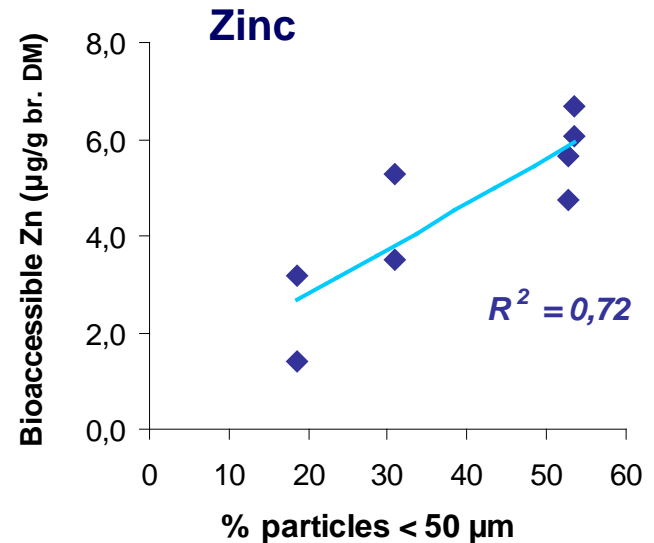
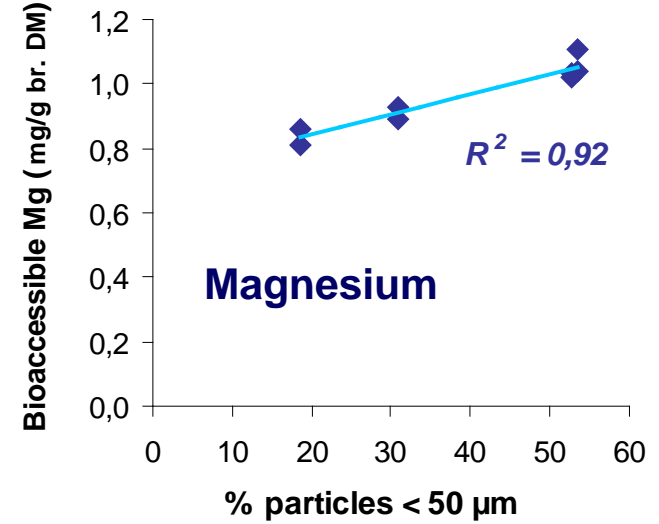
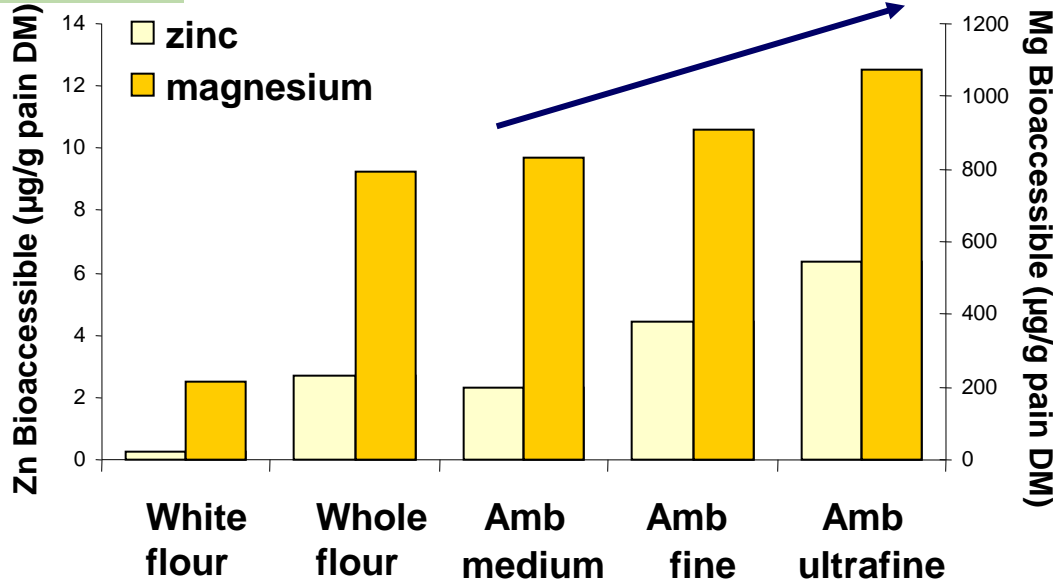
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Minerals bioaccessibility

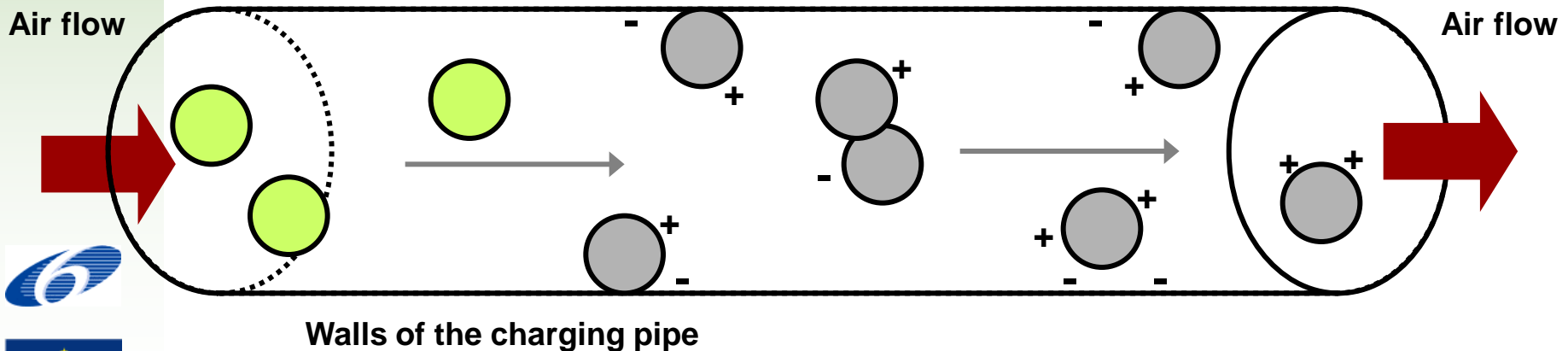
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- Minerals in aleurone cells
- Opening aleurone cells during grinding = increase bioaccessibility Mg et Zn
- Improvement nutrition quality of bread



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- Particles charged by rubbing against each other & the charging device walls.
- Materials : electron donor / electron acceptor → Behavior highly influenced by the surface properties of the particles (composition)
- The particles are then separated depending on the sign of their acquired charge.





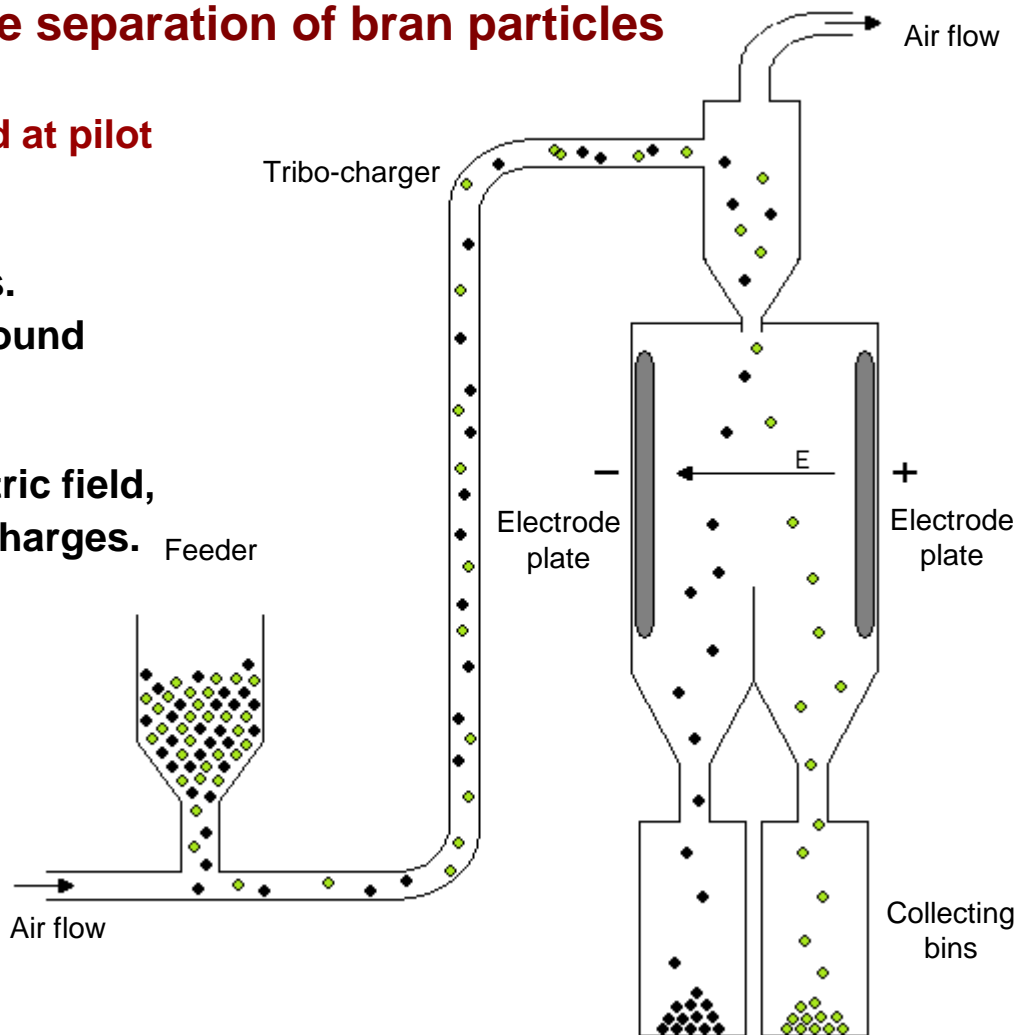
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Use of tribo-charging for the separation of bran particles

- **Electrostatic separation tested at pilot scale, after tribo-charging.**
- **3 successive separation steps. Starting material : ultrafine ground bran ($D_{50} \approx 50 \mu\text{m}$).**
- **Particles separated in an electric field, depending on their acquired charges.**
- **The dissociation of the different bran layers = important parameter**



pericarp **aleurone**



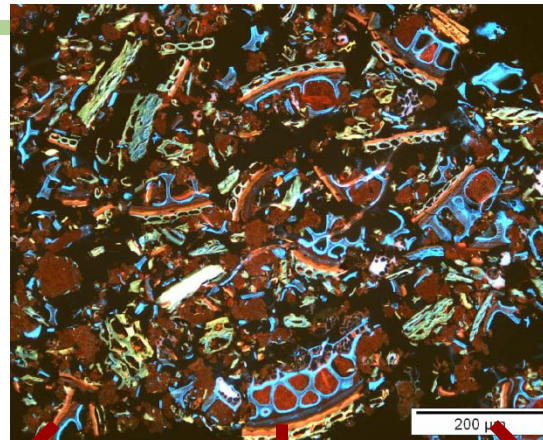


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**Electrostatic
pilot-separation**



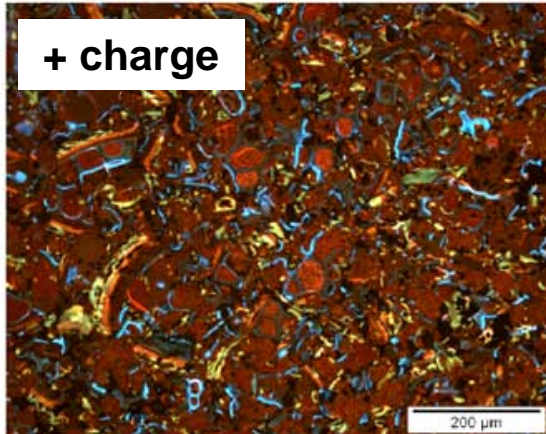
Starting material:

Cryogenized and micronized
Wheat bran

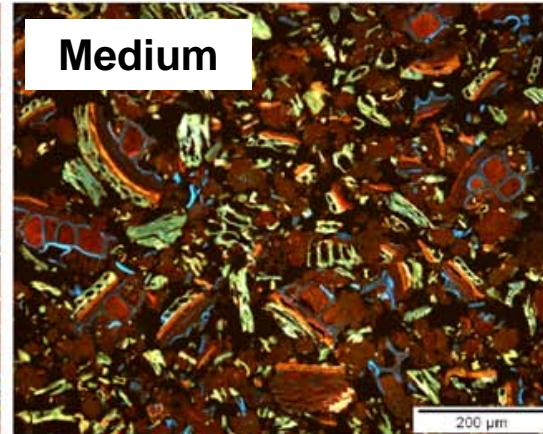
More aleurone
→ Ferulic acid,
folates, Mx...

More pericarp
and testa
→ Fibre rich

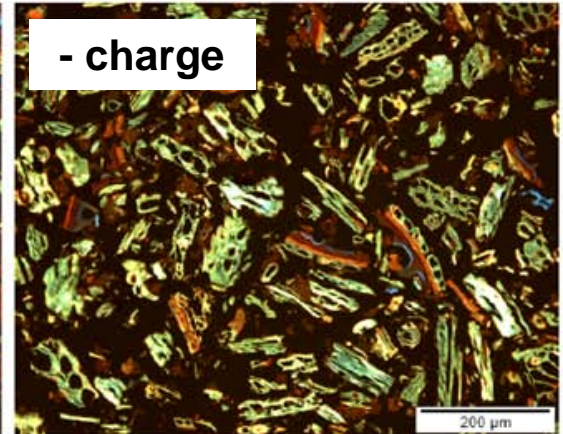
+ charge



Medium



- charge



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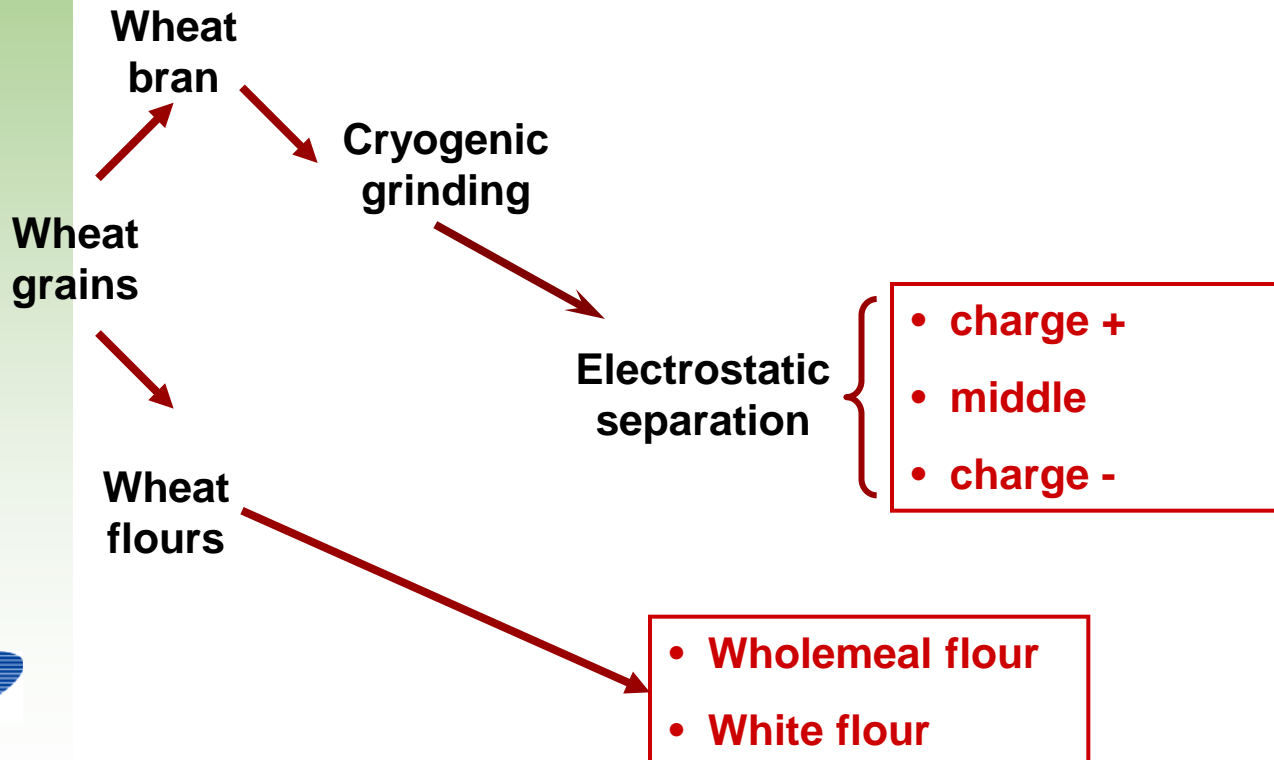
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Production of wheat fractions & breads



*Breadmaking : M. NOORT
TNO, the Netherlands*



- white bread
- whole bread

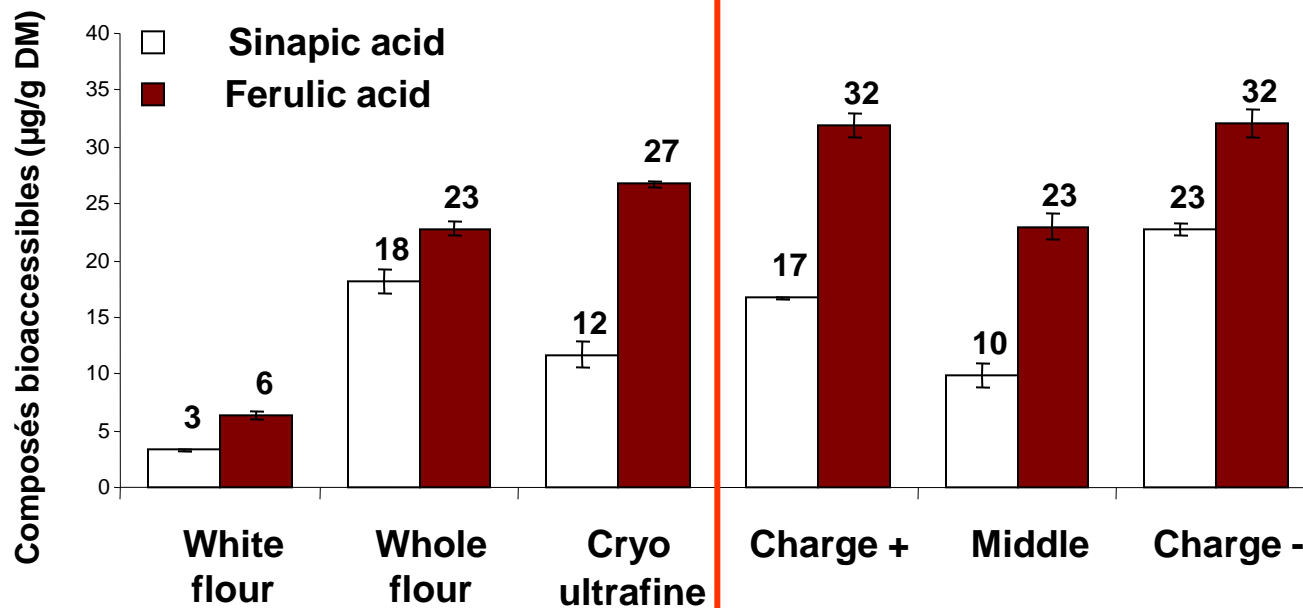
• bran breads
= whole breads, same ferulic acid and ash content



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2010**Electrostatic separation : phenolic acid bioaccessibility**

Electrostatic separation of micronized bran = better
bioaccessibility of phenolic acids than in starting bran

Changes in envelopes ratio in fractions = changes in bioactive
compounds bioactifs = ↗ nutritional interest of breads



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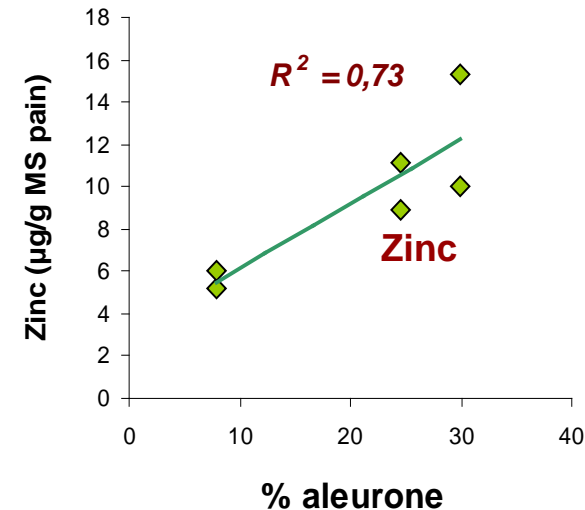
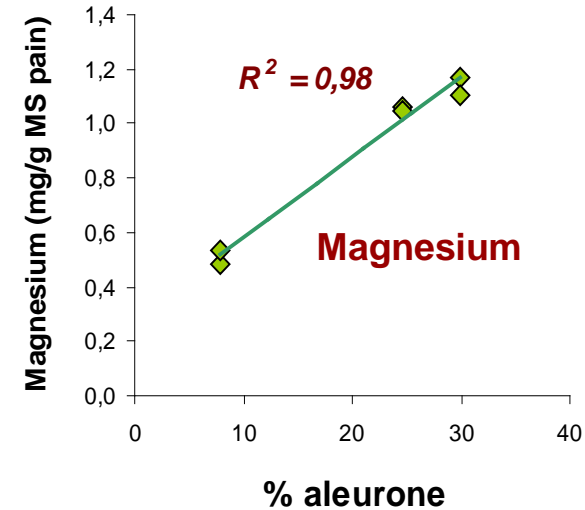
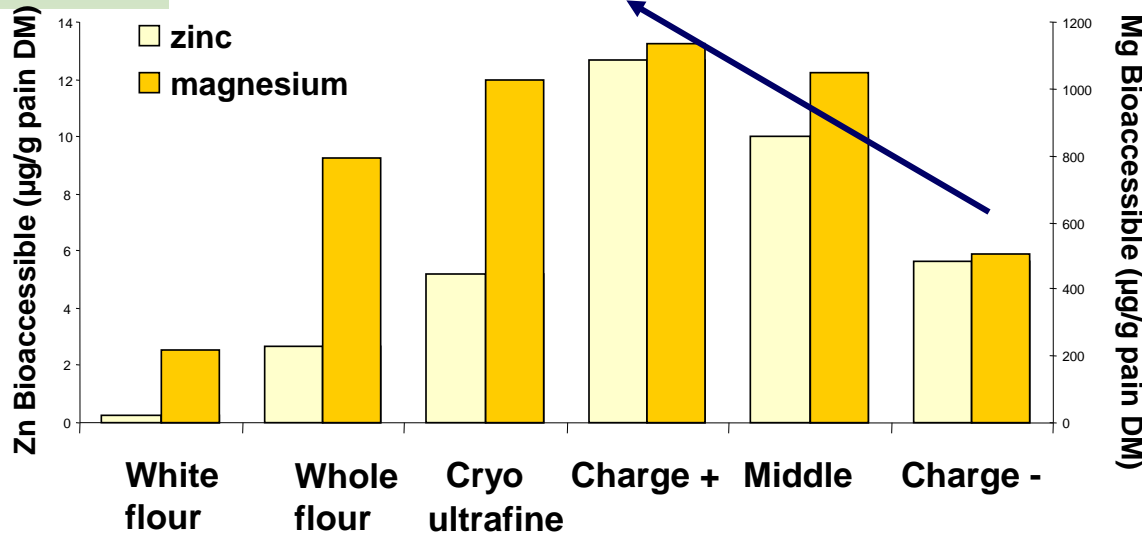
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Electrostatic separation : minerals bioaccessibility

Minerals bioaccessibility depends also on aleurone content in the fractions

Changes in envelopes ratio in fractions = changes in bioactive compounds bioactifs = nutritional interest of breads



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Conclusion

- Possible to produce food ingredients from bran bry dry processing
- Possible to improve the bioaccessibility of important compounds
 - in reducing the particle size
 - in selecting the tissues and sub-structures of interest
- evaluate the feasibility and costs of innovative processes
→ transfert to industry



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