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Institut National de la Recherche Agronomique

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Ecole Nationale Supérieure Agronomique

Workshop on Process Engineering of Cereals

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Programme and Abstracts

Workshop on
Process Engineering of Cereals

INRA – AGRO Montpellier
Cœur d'Ecole, Lecture Room 206

Friday 8 October 1999

Scientific Committee

Prof. Bernard Launay
Dr. Paul Colonna
Dr. Pierre Feillet
Prof. Stéphane Guilbert
Prof. Robert J. Hamer
Prof. George Jeronimidis
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Institut National de la Recherche Agronomique (INRA)

Ecole Nationale Supérieure Agronomique de Montpellier (AGRO)

American Association of Cereal Chemists (Europe Section)

International Association for Cereal Science and Technology (ICC)

2nd European Congress of Chemical Engineering (ECCE2)

Région Langedoc-Roussillon

for their support in the organisation and realisation of the Workshop.

Workshop
Process Engineering of Cereals

8 October 1999
INRA-ENSA campus of Montpellier, France

SCIENTIFIC PROGRAMME

8.00 a.m. – 8.45 a.m. Registration and Welcome of participants

8.45 a.m. - 9.00 a.m. Introduction of the Workshop, by **Prof. S. Guilbert**, AGRO-Montpellier

Session A: Grain Fractionation

9.00 a.m. - 10.00 a.m. **Heterogeneity of structure and grain composition**

- Conference presented by **Dr. M. Whitworth**, CCFRA, Chipping Campden, UK
- Discussion chaired by **Dr. J.-C. Autran**, INRA, Montpellier, France

10.00 a.m. - 11.00 a.m. **Mechanical properties of grain endosperm and ability to fractionation**

- Conference presented by **Dr. F. Mabille**, INRA, Montpellier, France
- Discussion chaired by **Prof. G. Jeronimidis**, The University of Reading, UK

11.00 a.m. - 11.45 a.m. Coffee break, poster session and/or visit of INRA-UTCA laboratories (on request)

11.30 a.m. - 12.45 a.m. **Processes of dry fractionation of starch and proteins**

- Conference presented by **Dr. O. Degant**, Alpine-Hosokawa, Augsburg, Germany
- Discussion chaired by **Dr. M.G. Lindhauer,** Federal Centre for Cereal, Potato and Lipid Research, Detmold, Germany

12.45 a.m. - 2.00 p.m. Lunch

Session B: Shaping of cereal doughs

2.00 p.m. - 3.00 p.m. **Rheology of wheat doughs**

- Conference presented by **Dr. P. Lillford**, Unilever, Bedford, UK
- Discussion chaired by **Prof. B. Launay**, ENSIA, Massy, France

3.00 p.m. - 4.00 p.m. **Mixing and aeration of cereal products**

- Conference presented by **Prof. G. Campbell**, The University of Manchester, UK
- Discussion chaired by **Prof. R.J. Hamer**, Wageningen Centre for Food Sciences, The Netherlands

4.00 p.m. - 5.00 p.m. **Heat treatments, structural modifications and characteristics of cereal end-products**

- Conference presented by **Prof. G. Trystram**, ENSIA, Massy, France
- Discussion chaired by **Dr. P. Colonna**, INRA, Nantes, France

5.00 p.m. - 5.30 p.m. **Synthesis of the workshop and recommendations in terms of research priorities**

- Chairman: **Dr. P. Feillet**, INRA, Montpellier, France

- Each of the six chairmen will be asked to present a 5-minute synthesis of his topic and to specifically draw *recommendations in terms of research priorities* for the future.

5.30 p.m. - 6.30 p.m. Social Event: Cocktail

TEXTS OF INVITED CONFERENCES

Session A : Grain Fractionation

Session B: Dough processing

LIST OF POSTERS

SESSION A : GRAIN FRACTIONATION

Heterogeneity of structure and grain composition

Discussion chaired by Dr. J.C. Autran

A.1 **Molecular basis of the wheat grain kernel hardness determined by confocal Raman microspectroscopy**, by *O. Piot, Autran J.-C. and M. Manfait*

A.2 **Self-glycosylating proteins are present in high molecular weight complexes in wheat endosperm**, by *S. de Pater, M. Kottenhagen, R. van Wijk, S.M.J. Langeveld, M. Vennik and J. Kijne*

A.3 **The behaviour of amyloplasts in developing wheat endosperm and the subcellular localization of self-glycosylating proteins**, by *S.M.J.Langeveld, R. van Wijk and S. de Pater*

A.4 **Friabilin hypothesis: a molecular model for endosperm texture in wheat**, by *P Greenwell*

A.5 **Occurrence of lignin in wheat bran: Possible association with suberin**, by *D. Crônier and B. Chabbert*

Mechanical properties of grain endosperm and ability to fractionation

Discussion chaired by Prof. G. Jeronimidis

A.6 **Heterogeneity for kernel hardness in wheat varieties as measured with a single kernel characterisation system**, by *M. Kelfkens and H. Bonthuis*

A.7 **Mechanical properties and structural characteristics on wheat bran**, by *S. Peyron, F. Mabille, J. Abecassis and J.-C. Autran*

A.8 **Determination of wheat grains grinding behaviour using an instrumented micromill and relation with the rheological properties of endosperm**, by *C. Létang, Y. Haddad, F. Mabille, J.-C. Bénet and J. Abecassis*

Processes of dry fractionation of starch and proteins

Discussion chaired by Dr. M.G. Lindhauer

A.9 **Prediction of particle size distribution arising from first break roller milling of wheat mixtures**, by *P.J. Bunn, G.M. Campbell and S.C.W. Hook*

A.10 **In flow milling product characterisation by image analysis**, by *J.M. Roger, J. Abecassis, S. Guillaume, M. Chaurand, M. Crochon and V. Bellon-Maurel*

A.11 **Effect of dry milling conditions on the separability of wheat kernel constituents**, by *D. Bordeaux, J.-C. Benezet, L. Clerc, A. Benhassaine, M. Chaurand, J.-C. Autran and J. Abecassis*

A.12 **Composted wheatfeed, processing and horticultural applications**, by *S.P. Cauvain, A.D. Evers and P. Wallace*

A.13 **Poster Alpine Hosokawa**

MOLECULAR BASIS OF THE WHEAT GRAIN KERNEL HARDNESS DETERMINED BY CONFOCAL RAMAN MICROSPECTROSCOPY

O. Piot [1], J.-C. Autran [2] and M. Manfait [1]

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Aims

Few things are known about the molecular basis which are involved in the wheat grain fractures induced during the first transformation of the wheat (milling process). The aim of our work is to use spectroscopic technique, particularly Raman scattering spectroscopy, in order to characterise the nature and the structure of the molecular species responsible of the *Triticum aestivum* wheat grain cohesion. The present work is more particularly focused on the kernel hardness. Indeed a better understanding of the molecular basis involved in the kernel cohesion could lead to an improved control of fragmentation during the milling process, and therefore to an increase of the milling value of wheat grains.

Nature of the study

Raman spectroscopy permits to identify in situ molecules and to characterise the binding between the molecular components of a sample. It is a non destructive analytical technique and is rapidly performed. Moreover, the coupling between a Raman spectrometer and an optical microscope with respect of confocality brings to the technique a spatial resolution at the micrometer scale. For instance, such analytical technique permits to determine the composition of the kernel and of the aleurone cell layer, and reveals molecular heterogeneity within the starchy endosperm and between aleurone cell walls.

Several hypothesis have been emitted about the molecular species responsible of the kernel cohesion and about the factors which influence the hardness. Indeed, the level of hardness would depend not only on the nature of the protein matrix, but also on the interface between starch granule and protein matrix. Specific protein, such as puroindoline-b or friabiline, and/or lipid component are likely to be involved in the kernel cohesion. Moreover, the role of endosperm cell walls has not yet been determined in the grain grinding ability.

Materials and methods.

Experiments were carried out on wheat (*Triticum aestivum*) samples supplied by INRA (Montpellier, France) and Champagne Céréales (Reims, France).

Investigations were led on wheat varieties of different levels of hardness and at different maturation stages, in order to underline differences in structure between *soft* and *hard* varieties. Raman spectra were recorded on 50 µm thick sections of wheat grain. Various reference products such as arabinoxylans and protein fractions were extracted and purified by INRA Montpellier.

Investigations were conducted using a Labram microspectrometer (Dilor, France) equipped with He/Ne laser as excitation source. The choice of a red excitation (632.8 nm) permits to obtain an intense Raman scattering of the wheat components and similarly by avoiding parasite fluorescence. It is also possible to adapt a moving XY plate in order to construct spectral imaging.

Results.

The protein content of the starchy endosperm has been characterised in situ. It appears a more important protein quantity in the subaleurone endosperm than in the central part of the kernel. The protein distribution within the starchy endosperm has been mapped by constructing spectral images. We have determined not only the primary structure of the protein matrix in various amino acid residues (phenylalanine, tyrosine, tryptophan) but also its secondary conformation. It has been underlined that the distribution of the protein α-helical structure, β-sheet or random coil is a good indicator of the kernel hardness. Indeed, it appears that α-helical structure gets more important during the kernel ripening, and that the *hard* variety has a proportion in α-helix much greater than the *soft* variety at the same maturation step. In order to go further in the molecular determination of the interface between the starch granules and the protein matrix, lipid content has also been investigated by using specific Raman vibrations of lipids. Preliminary results shows that the lipid content is localised at the starch granules contour. Concerning the role of the endosperm cell walls in the hardness criterion, the structure of the endosperm cell walls has been determined by comparing with reference arabinoxylans chains, of which the number of xylose, arabinose and ferulic ester is well controlled. It is therefore possible to determine the length of the arabinoxylans chain and the binding between the chains and the neighbouring molecules, for grains of different levels of hardness.

Conclusion

The use of spectroscopy in cereal science had already permitted to determine the protein and lipid contents of a cereal grain. The development of microspectroscopic technique offers the advantages of an in-situ and non destructive analysis, at the micrometer scale. It is now possible to characterise the molecular nature of the interface starch granule – protein matrix and of the endosperm cell walls. Moreover, vibrational spectroscopy such as FTIR or Raman gives information about the secondary structure of the protein. For instance, the distribution in α helical structure has been correlated with the hardness of the wheat grain kernel. In further investigations, we will extend our work to the fracture zones of the milling products at each grinding step of the mill. The aim is to achieve a 3D characterisation of fracture zones by Raman spectral imaging.

Poster A.7

MECHANICAL PROPERTIES AND STRUCTURAL CHARACTERISTICS OF WHEAT BRAN

S. Peyron, F. Mabille, J. Abecassis and J.-C. Autran

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Aim

The milling process is based on the elasticity and friability difference between endosperm and external parts of grain. During grinding, the grain envelopes are reduced to bigger particles than those of endosperm. Friability of wheat bran is then a relevant factor of separation between bran and kernel. This study describes an original method for isolating wheat bran samples. The objective was to charaterize the mechanical properties of isolated wheat bran samples and to explain these properties on the basis of stuctural characteristics of aleurone layer and pericarp.

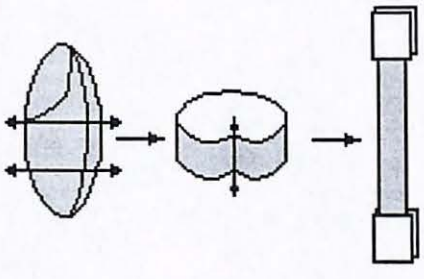
Materials and methods

The durum wheat variety Ardente (1998 harvest year) was obtained from Sud Céréales (Arles - France).

Preparation of wheat bran strips

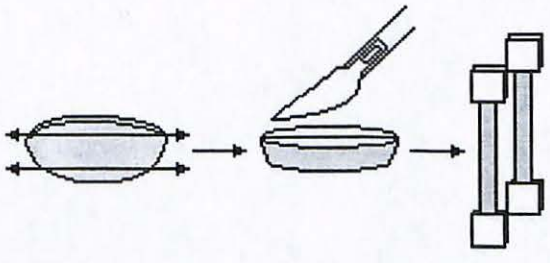
Radial orientation

Wheat grains were immersed in distilled water during 10-12 hours. Grain ends were cut and eliminated. The remaining part was soaked again for 1-2 hours. An incision was made in the crease and the endosperm was eliminated using a scapel. After rinsing, the bran strips were dried between two slides to impose them a plane shape. Strip tips were stuck between two pieces of a plastic sheet to allow the fixing in the TAX-T2 texturometer.



Longitudinal orientation

The dorsal and ventral parts of the grain were sandpapered so as to get them a plane form. After 6 hours of immersion, the disc was divided in two parts by incising the crease. Every part was soaked again and the endosperm was eliminated. After rising, the two strips were dried between two slides and prepared alike for fixing in the texturometer. The aleurone layer strips were obtained by pericarp elimination using a needle.



Sample testing

Samples were set to reach balanced conditions with saturated salt solution at 30°C and 76% relative humidity for 48 h so that the strip moisture content stabilised at about 17%, a moisture content generally used in wheat milling. Uniaxial tension tests were performed using a static texture analyser (Rheo TAX-T2/25).

Environmental scanning electron microscopy
Strips were examined in an ESEM Philips scanning electron microscope.

Results

Bran strips were constituted of either the whole grain envelope (aleurone layer, seed coat and pericarp) or the only aleurone layer. The two kinds of strips were tested in radial and in longitudinal orientation. The results of uniaxial tension tests are reported in the figure 1.

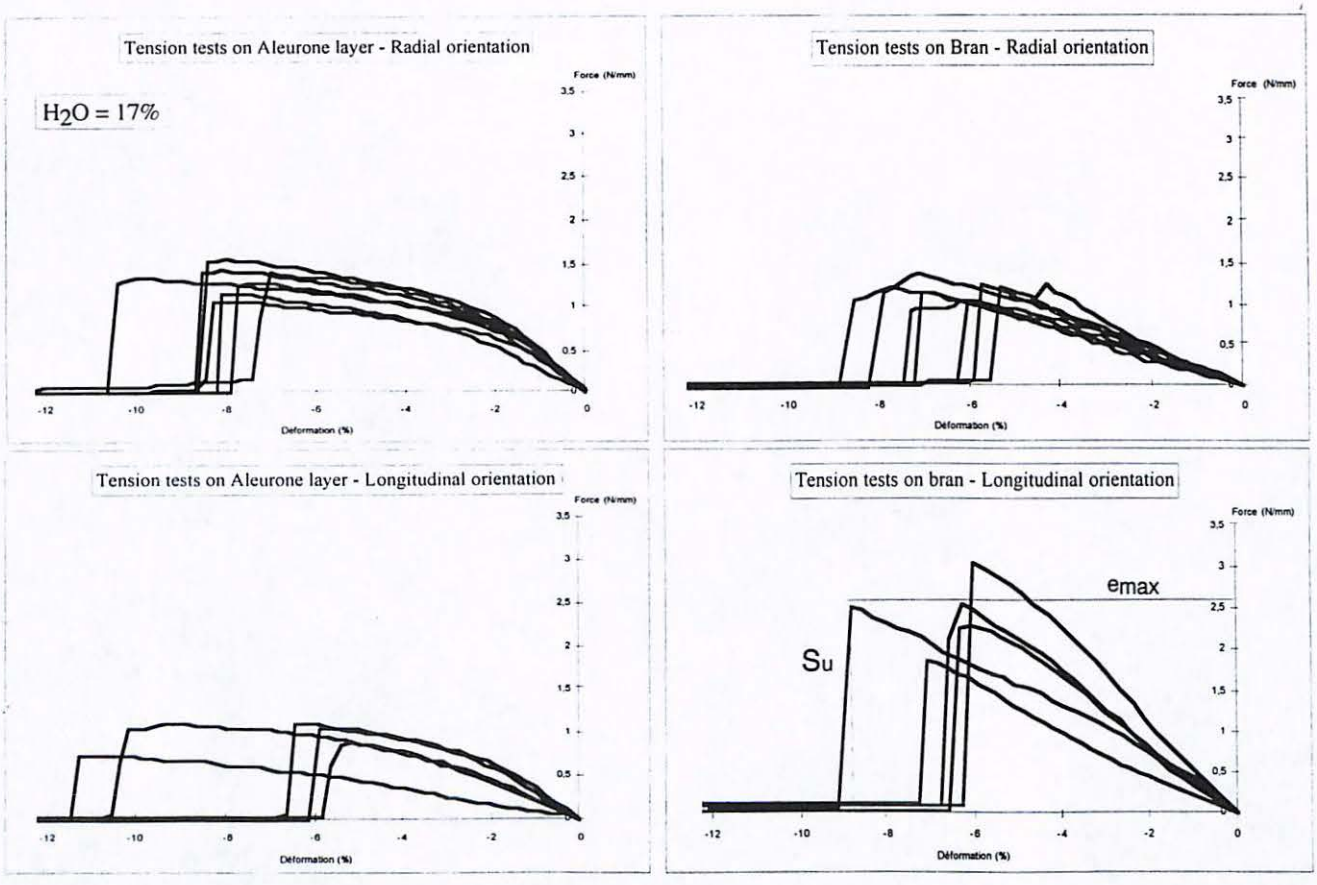


figure 1 : Force-deformation Curves of aleurone layer and bran strips in longitudinal and radial orientation

Effect of Bran orientation

No significant difference in mechanical properties of aleurone layer strips due to the orientation could be observed. Tensile strength (S_u) and deformation to rupture (e_{max}) were similar for radial and longitudinal strips. This reveals the isotropic character of the aleurone layer.

On the other hand, the measurements carried out on bran strips reveal significant differences according to the orientation. The results obtained with longitudinal bran strips were comparable with those obtained with the aleurone layer strips. In this orientation, the pericarp does not influence the envelope strength. In the radial orientation, the S_u and e_{max} values are significantly higher than those obtained with radial strips.

In addition, the curves obtained with bran strips reveal a fragile behaviour. On the curves obtained withe aleurone layer strips, the presence of a plastic stage was characteristic of a ductile behaviour. The pericarp is then responsable for the anisotropic character and for the fragile behaviour of wheat bran.

Structural study of pericarp and aleurone layer by environmental scanning microscopy.

In order to explain the anisotropic character of wheat bran, the structure of different tissus was studied by environmental scanning microscopy.

The aleurone layer is one cell thick. The cells are polygonal without intercellular spaces and have thickened cell walls (6-8 µm thick).

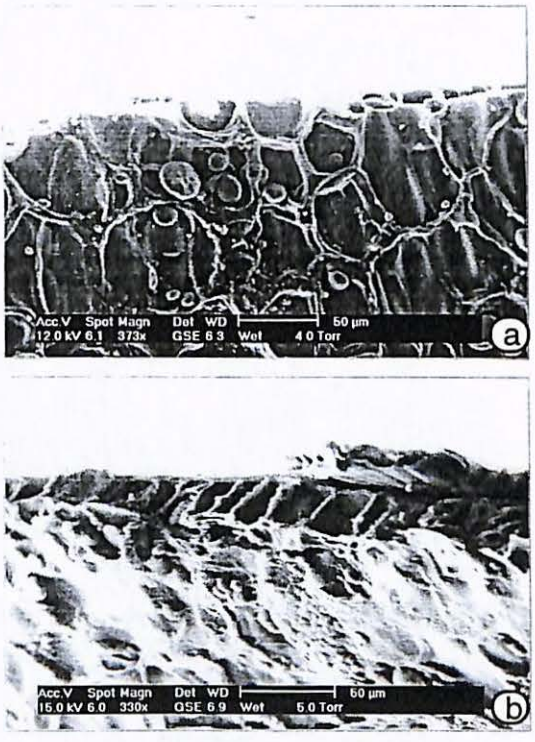


Figure 2 show that fracture does not happen on the level of cell walls but through cells. It is difficult to attribute the resistance of aleurone layer to the only cell walls. However, considering the aleurone cells shape, the cell walls form a regular network. This could explain the isotropic character of this tissu. Whatever the direction of traction force may be, the resistance provided by the cell walls are identical.

Figure 2 : Extremities of aleurone layer strips
a : inner starchy endosperm face
b : line of rupture of aleurone layer

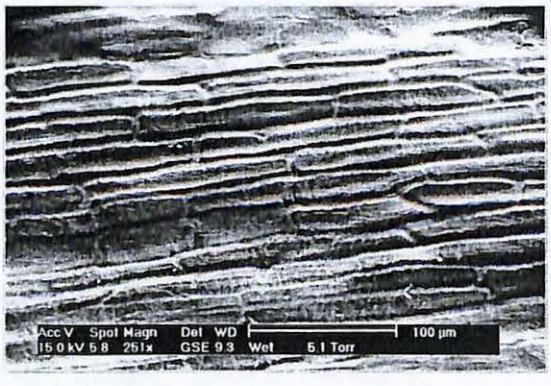


Figure 3 : Outer face of pericarp

The pericarp is composed of several layer. The outer epiderm of the pericarp is composed of long narrow cells that are arranged alternately.
If the traction force is exerced perpendicular to the cells, the resistance provided by the cell walls is lower than in the parallel direction. This particular stucture explains the anisotropic nature of pericarp.

Conclusion

The method developed for measuring mechanical properties of wheat bran proved to be adapted to this biological material. Despite the variability in the data obtained from every test this method proved to be precise enough and allowed to determine the contribution of the pericarp and the aleurone layer to the mechanical strength of bran.

The environmental scanning microscopy proved to be an adapted tool for the structural study of tissus. Structural characteristics observed by microscopy allowed to explain the mechanical properties of wheat bran and to understand the role played by the different histological layers of bran.

EFFECT OF DRY MILLING CONDITIONS ON THE SEPARABILITY OF WHEAT KERNEL CONSTITUENTS

D. Bordeaux [1], J.-C. Benezet [1], L. Clerc [1], A. Benhassaine [1], M. Chaurand [2], J.-C. Autran [2] and J. Abecassis [2]

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Introduction

The valorisation of cereals in non alimentary industries use the development of new separation technology between the different constituents: starch, proteins (constituents of endosperm) and fibers (constituents of bran). In fact, only pure fractions are valorisable in non alimentary industries as chemistry industries.

For the separation and the purification of wheat fractions, we can use two different ways: a dry separation (milling, sieving) or a wet separation.

The possibility of use the wheat kernel as raw material must suppose not only the amelioration of separation of constituents but also the reduction of price production..

At the present time, only the wet treatment can permit to obtain a relatively pure starch fraction. But, this type of separation will become too expensive because of the increase in price of water treatment.

That's why, we decided to set up a program for the optimisation of dry milling of wheat.

In this communication, we present some first works which concern the optimisation of different milling methods.

Milling - Separation

We have considered the milling of wheat by three grinders which are different from the usual cylinders milling.

We can use four types of stress during milling. The stress can be: percussion of a grinding materiel or percussion against a fixed element, compression between a fixed

element and a mobile one, shearing with help of sharp materiel or attrition between rough surfaces.

These types of stress may be combined in one grinder.

In function of intensity and mode of stress, every constituent may have a different comportment during the grinding.

As well as we may separate the constituents in function of their form, their size or their density.

We have made a parametric study with three different grinders to optimise the separation between the principal components of wheat. We have compared these millings with the usual one.

We choose for our study the three following grinders: a millstone, a percussion grinder and a centrifugal grinder.

Results

The fibers and the others components are separated with the usual process. The separation between starch and proteins requires the study of the ground product finer than 200 µm.

We can distinguish different size of populations:

- a fraction constituted by particles superior to 50 µm, which is characterised by aggregates of starch and proteins
- in the second fraction, around 30 µm, we find unblocked starch grain, relatively pure and mixed with proteins
- the last population, around 5 µm, is constituted by unblocked starch grain, with finer size

By selection and using different size cuttings we obtain a different composition.

The incidence of grinding conditions has been compared by the following different physico-chemical approaches:

- grinding kinetic variation of size and the form of the particles
- evolution of the biochemical composition of the population (content of the different components)

Conclusion

Grinding of wheat by different mode of stress show us different granulometric distributions in the population less than 200 µm.

The proportion of the three observed populations varies in function of the grinding parameters and of type of grinder.

The different modes of applied stress have allowed to obtain flour with different size distribution;

The final results have allowed to define optimal conditions and separation process in accordance with the inquired characteristics.

ABSTRACTS OF POSTERS

SESSION B : DOUGH PROCESSING

Rheology of wheat doughs

Discussion chaired by Prof. B. Launay

B.1 **Influence of hydration on wheat flour cohesive properties**, by *J.M.C. Da Costa, J. Scher and J. Hardy*

B.2 **Effect of arabinoxylans on mixing properties of wheat gluten**, by *E. Labat, M.-H. Morel and X. Rouau*

B.3 **Destructuration of low hydrated starch processed under shear**, by *C. Barron, G. Della Valle, P. Colonna and B. Vergnes*

Mixing and aeration of cereal products

Discussion chaired by Dr. R.J. Hamer

B.4 **Frozen bread dough: Impact of the freezing rate and the storage duration on gassing power**, by *M. Havet and A. Le Bail*

B.5 **Influence of formulation and mixing time on breadmaking qualities of French frozen dough**, by *J. Rouillé and A. Le Bail*

B.6 **Baking expansion mechanism of sour cassava starch (*Polvilho Azedo*)**, by *A.C. Bertolini, C. Mestres and P. Colonna*

Heat treatments, structural modifications and characteristics of cereal end-products

Discussion chaired by Dr. P. Colonna

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WORKSHOP ON PROCESS ENGINEERING OF CEREALS

SECRETARIAT

INRA - UTCA - N. VOLLE

2, Place Pierre Viala

34060 MONTPELLIER CEDEX 1 - FRANCE

Stamp required

GENERAL INFORMATION

Location and date

The **Workshop on Process Engineering of Cereals** will be held at

INRA-AGRO Montpellier
2 Place Pierre Viala
34060 MONTPELLIER CEDEX 1, FRANCE

on 8 October 1999

Wheather

in October, the weather is comfortable in Montpellier, averaging 18°C.

Registration fees

Participants	Before June 30th	After June 30th
Standard Delegate	1 000 FF 152,45 €	1 200 FF 182,94 €
Delegate to ECC2 and Student	500 FF 76,22 €	600 FF 91,46 €

The participant fees include : the booklet of abstracts, the lunch and mid session refreshments.

Language

The official Workshop language will be English.

Accomodation

If you need help for hotel accomodation please contact the secretariat of the workshop.

MEETING INFORMATION

Process Engineering of Cereals
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First circular

Workshop on Process Engineering of Cereals

Friday 8 October 1999

INRA - AGRO Montpellier France

agro Montpellier
Ecole Nationale Supérieure Agronomique

INRA
Institut National de la Recherche Agronomique
CENTRE DE MONTPELLIER

Aims of the workshop

Following the " 2nd European Congress of Chemical Engineering (ECC2)" in Montpellier, a special one-day workshop (Friday 8 october 1999) will present recent advances on Process Engineering of Cereals.
The aims of this Workshop are to update knowledge and identify technological bottlenecks in the field of cereal processing, including:

- grain fractionation (fragmentation, milling, separation, ultrafine grinding, ...),
- dough processing (dough formation, rheological properties, heat treatments, ...),

so as to draw recommendations and research priorities in this field.

Workshop organization

The Workshop will consist of :

- Six invited conferences (30 min), each of which followed by a round-table discussion (30 min).
- A poster session fitting with the aims of the workshop. Selected posters' authors will be invited to participate to round-table discussions.
- A conclusion session aimed at drawing recommendations in terms of research priorities.

The synthesis of the Workshop will be submitted for publication, e.g. in the Cereal Foods World Journal.

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J-C. Autran
N. Volle

Introducing conferences to round-tables

- ***Heterogeneity of structure and grain composition***
  Dr. M. Whitworth, CCFRA, Chipping Campden, UK.
- ***Mechanical properties of grain endosperm and ability to fractionation***
  Prof. J-C. Bénet, Montpellier University, France
  Dr. F. Mabille, INRA, Montpellier, France
- ***Processes of dry fractionation of starch and proteins***
  Dr. O. Degant, Alpine-Hosokawa, Augsburg, Germany
- ***Rheological properties of cereal doughs***
  Dr. P. Lillford, Univeler; UK.
- ***Mixing and aeration of cereal products***
  Dr.G. Campbell, University of Manchester, UK.
- ***Heat treatments, structural modifications and characteristics of cereal end-products***
  Prof. G. Trystram, ENSIA, Massy, France

Instructions to authors of posters

Submission deadline : June 30th, 1999

- Please send back one form with a floppy disk
- Please submit structured texts (2 pages written in English): "Aims, Nature of the study, Materials and methods, Results and Conclusion " .
- Start with the title in CAPITAL LETTERS.
- Skip a line and then list author(s) surname(s) first, followed by the initial(s) of the first name(s) and the affiliation(s). The name of author who will be present at the meeting should be underlined.
- Skip a line between the authors and the beginning of the text.
- Typography : Type the text single-spaced in Times 11 (from 500 to 1000 words).

Important Deadlines

June 30th, 1999 - Poster submission deadline

July 15th, 1999 - Poster acceptance and selection in view of the round-table discussions

Process Engineering of Cereals

Please return this form by June 30th, 1999

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