

MECHANICAL PROPERTIES AND STRUCTURAL CHARACTERISTICS OF WHEAT BRAN

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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 characterize the mechanical properties of isolated wheat bran samples and to explain these properties on the basis of structural characteristics of aleurone layer and pericarp.

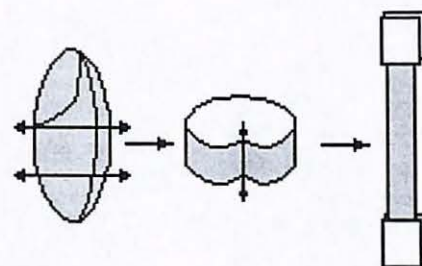
Materials and methods

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

Preparation of wheat bran strips

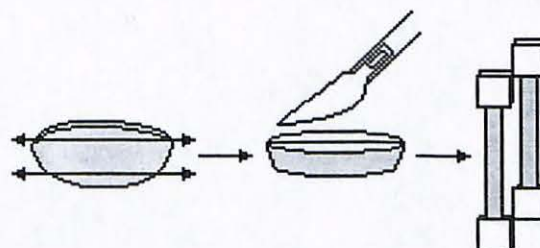
Radial orientation

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 rinsing, 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.

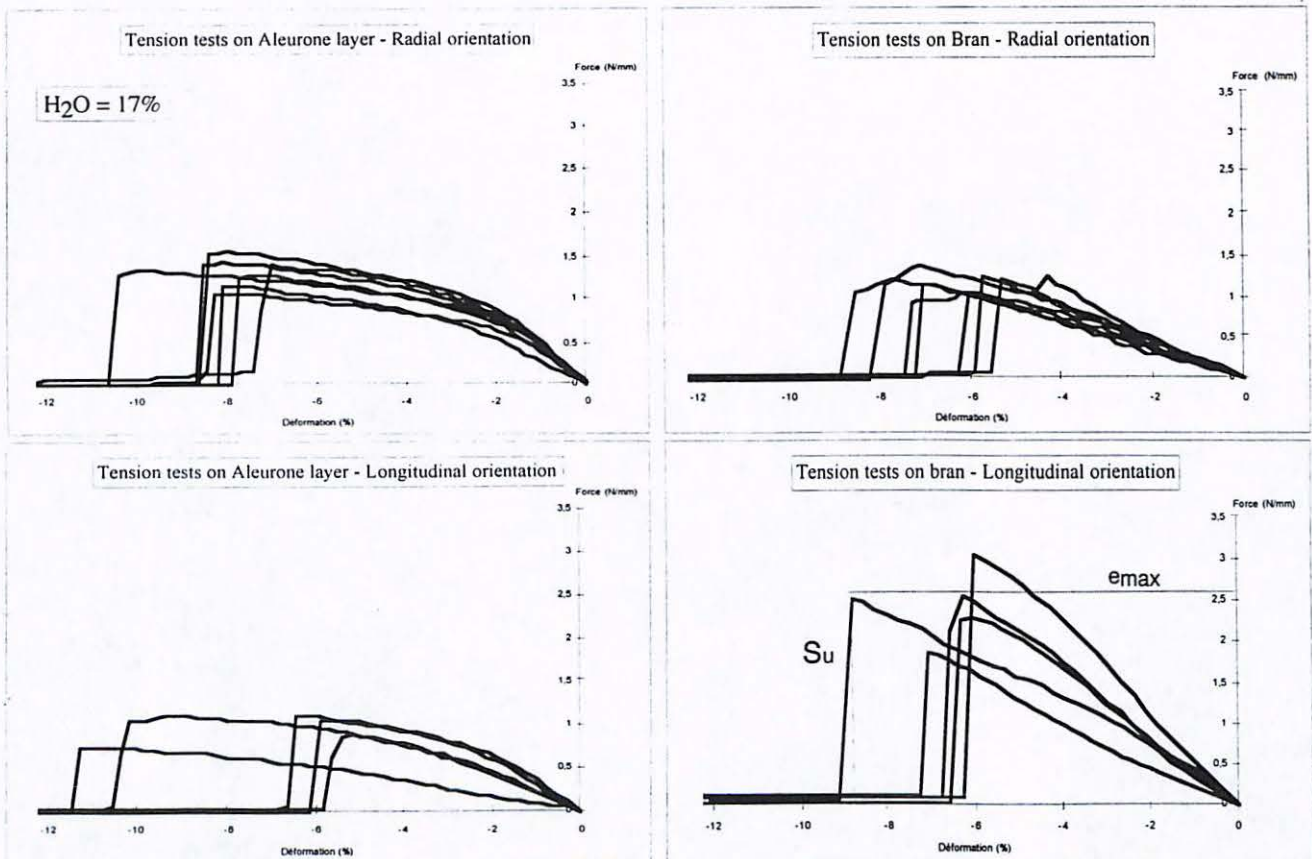


figure 1 : Force-deformation Curves of aleurone layer and bran strips in longitudinal and radial orientation

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 with aleurone layer strips, the presence of a plastic stage was characteristic of a ductile behaviour. The pericarp is then responsible 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 tissues 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).

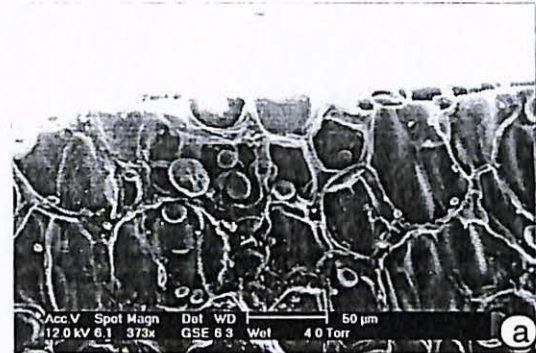


Figure 2 show that fracture does not happen on the level of cell walls but through cells. It is difficult to attribute the resistance of aleurone layer to the only cell walls. However, considering the aleurone cells shape, the cell walls form a regular network. This could explain the isotropic character of this tissue. 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

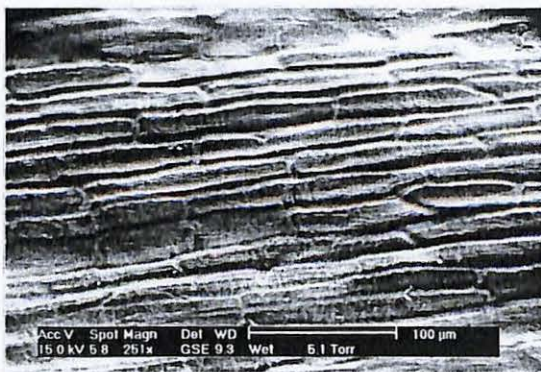


Figure 3 : Outer face of pericarp

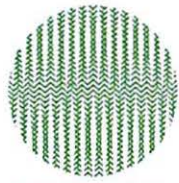
The pericarp is composed of several layer. The outer epiderm of the pericarp is composed of long narrow cells that are arranged alternately.

If the traction force is exercised perpendicular to the cells, the resistance provided by the cell walls is lower than in the parallel direction. This particular structure 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 tissues. 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.



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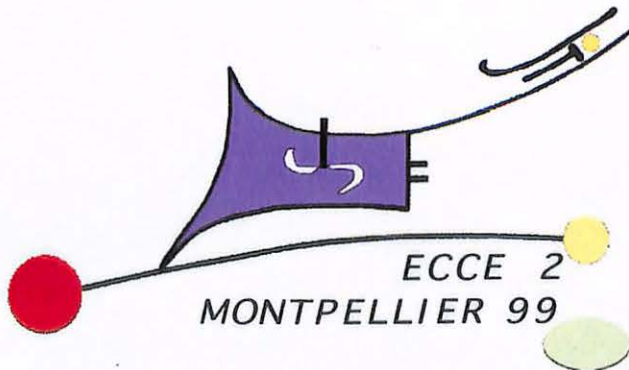
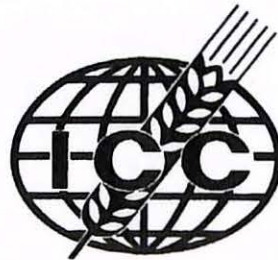
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