

## **RELATIONSHIP BETWEEN THE STRUCTURE AND THE RHEOLOGICAL PROPERTIES OF DURUM WHEAT BRAN**

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### **ABSTRACT**

A method was developed to prepare bran and aleurone layer strips in radial and longitudinal orientations of the grain. These strips were submitted to traction tests until disruption using DMTA with a new system of humidity control. Rheological measurements (stress and energy of rupture) in both orientations were carried out in order to determine the contribution of the aleurone layer and of the pericarp to the mechanical resistance of wheat bran. In addition, each tissue was observed in ESEM (environmental scanning electronic microscopy).

**Keywords:** aleurone layer, bran, friability, rheology

### **INTRODUCTION**

The milling process is based on difference in elasticity and friability between endosperm and peripheral parts of grain. During grinding, the grain envelopes are reduced to bigger particles than those of endosperm. A high friability of envelopes supports the contamination of semolinas by bran particles and this factor is then decisive in the separation between bran and endosperm. This study describes an original method for isolating wheat bran samples. The objective was to characterise the rheological characteristics of isolated wheat bran samples and to explain these properties on the basis of aleurone layer and pericarp structure.

### **MATERIAL AND METHODS**

The durum wheat (*Triticum durum* Desf.) used was cv. Ardente grown in 1999 (INRA, Melgucil, France). Grains were dissected in order to obtain test samples of bran and aleurone layer for radial and longitudinal orientation.

#### *Radial orientation*

Wheat grains were immersed in distilled water during 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 scalpel. After rinsing, the bran strips

were dried at 25 °C between two slides to impose them a plane shape and a moisture content of 12% (Figure 20).

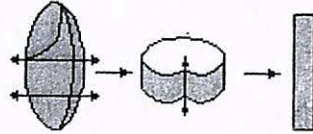


Figure 20 - Isolation of transversal strip

#### Longitudinal orientation

The dorsal and ventral parts of the grain were sand-papered so as to give them a plane form (Figure 21). After 10 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 at 25 °C. The aleurone layer strips were obtained by pericarp elimination using a needle.

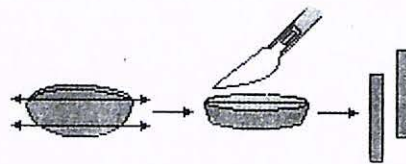


Figure 21 - Isolation of longitudinal strip

#### Sample testing

Mechanical tests were performed using Dynamic Mechanical Thermal Analysis DMTA Mk III E (Rheometrics Inc., Piscataway, USA). Humidity control was achieved according to the principle of water vapour saturation at different temperatures. The furnace was flushed with air that was bubbled through water at 25.2 °C. Chamber relative humidity was fixed at 78% RH. This process allowed to impose a water content of 17% in the sample during the test. Sample equilibration was followed by a time sweep test at imposed strain (0.01%), (Total time = 10 min; frequency = 1.59 Hz, furnace temperature = 30 °C). The stability of elastic modulus ( $E'$ ) was used as an indicator of the sample equilibration.

Uniaxial tension tests were performed at a constant strain rate of 0.05 mm/s until disruption of the sample. Stress-strain curves were used to determine mechanical parameters: maximum tensile strain ( $\epsilon_{\max}$ ), stress of rupture ( $\sigma_{\max}$ ), elastic modulus ( $E'$ ) and energy of rupture ( $W_{\max}$ ). Tension tests were performed on at least 10 bran strips. Tests whose failure did not occur in the middle of the strip were discarded.

#### Environmental scanning electron microscopy

Strips were examined in an ESEM Philips scanning electron microscope (G x 250-350).

## RESULTS

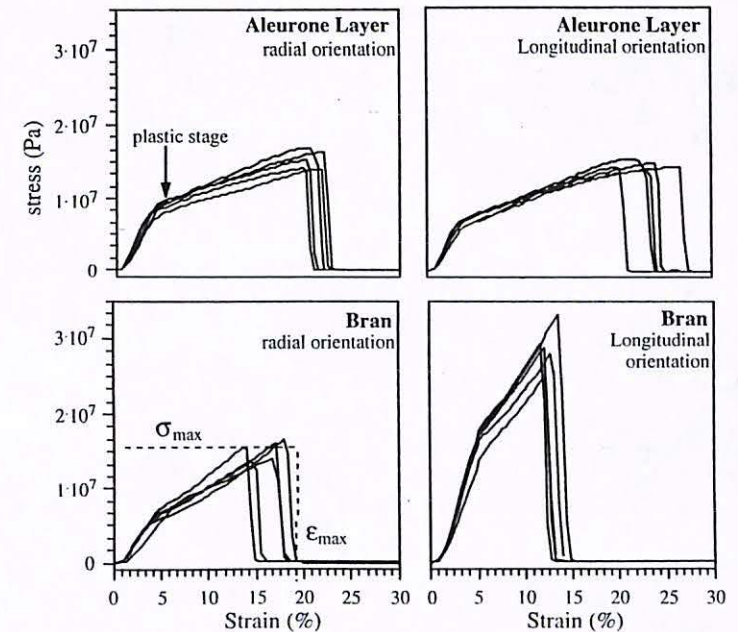


Figure 22 - Stress-strain curves of aleurone layer and bran strips in longitudinal and radial orientation

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 Fig. 22.

Stress-strain curves presented two linear parts with distinct directing coefficients corresponding to an elastic then plastic strain of the sample. Variation of slope represents the elasticity threshold (or plastic stage) of material.

### *Effect of Bran orientation*

No significant difference in rheological properties of aleurone layer strips due to the orientation could be observed. Similar stress to rupture ( $\sigma_{max}$ ) and strain to rupture ( $\epsilon_{max}$ ) for radial and longitudinal strips revealed the isotropic character of the aleurone layer.

On the other hand, the measurements carried out on bran strips revealed significant differences according to the orientation. Whereas the strain at failure was similar in two orientation, the stress to rupture was twice higher in the longitudinal orientation. Regarding the isotropic nature of aleurone layer, this anisotropy could be assigned to the pericarp. In radial orientation, its contribution to the mechanical resistance of bran was negligible but the outer layer of pericarp induced a significant increase in the tensile strength of bran in longitudinal orientation.

The pericarp was then responsible for the anisotropic character 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 (Fig. 23) and have thick cell walls (6-8  $\mu$ m thick).

Considering the cells shape, the cell walls form a regular network which could explain the isotropic character of this tissue. Whatever the direction of traction force, the resistance provided by the cell walls is identical.

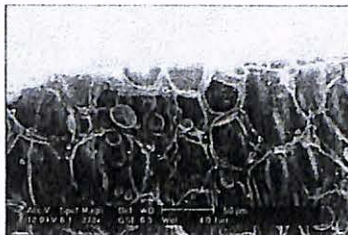


Figure 23 - Extremity of aleurone layer strip

The pericarp is composed of several layer. The outer epidermis of the pericarp is composed of long narrow cells that are arranged alternately (Figure 24).

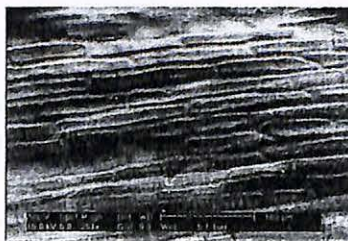


Figure 24 - Outer face of pericarp

If the traction force was applied perpendicular to the cells (longitudinal orientation of the test), the resistance provided by the cell walls is lower than in the parallel direction (radial orientation). This particular structure explains the anisotropic nature of pericarp.

### **CONCLUSION**

The couple approach of structural and rheological characterisation of grain tissues seemed to be adapted to understand the properties of wheat bran. The variability in the rheological data (10-15%) showed that this method proved to be precise enough to determine the contribution of the pericarp and the aleurone layer to the mechanical strength of bran. Works are in progress to study the effect of different factors on mechanical properties of durum wheat bran and on genetic variability in view of better understand the milling value of durum wheat.