MODULUS OF ELASTICITY OF RAPESEED SHELL

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INTRODUCTION

Rapeseeds are subjected to various external forces at all stages of harvesting, transport, cleaning, drying, loading, etc. All these processes result in a considerable kernel damage that in turn lowers both the quantity and quality of these seeds. Even a small injury of the rapeseed shell induces chemical reactions of oil contained in the seed leading to a decrease of its quality. Information on the mechanical properties of rapeseed shell would aid designig grain-handling equipment so as to minimize seed shell damage.

Several research studies have been conducted to determine physical parameters of rapeseed. The most important of these dealt with the strength of the seeds subjected to different external loads. Szot and Kutzbach (in press) studied the resistance of single rapeseed to impact. Szot and Stępniewski 1991 compared some seed mechanical factors in the case of some chosen rape varieties. The influence of higher temperature of rapeseeds on their mechanical resistance was studied by Szot et al. 1989. But only Davison et al. 1975 studied both mechanical properties of the whole rapeseed as well as mechanical properties of the rapeseed shell.

The present investigations were aimed at working out a new method of rapeseed shell testing and determination of the modulus of elasticity of rapeseed shell at various moisture contents. The comparison of the shell modulus of elasticity of various rape varieties was also attempted.

MATERIALS AND METHODS

The fact that the stripes cut from the rape shell are small causes problems with fixing the ends of the sample in the standard holders used in the tension tests. When only weak pressure is applied at the holders' surface the samples slip off during testing (especially when they are wet); on the other hand, the pressure that is too strong crushes the sample causing damage at the ends of the holder edges in most cases. Davison et al. 1975 used glue for fixing the sample stripes in the tension tests. Narrow strips were cut from the shell of whole kernels and both ends of each strip were glued onto separate pieces of glass. After the glue had hardned, this glass test fixture was mounted in specially designed jaws and subjected to tensile loads in the Instron machine. The above method was used for dry samples (7.2% m.c.) only.

Szot et al. 1989 worked out a method of measuring the resistance to tension of the pea seed shell. The method applied a tension test, which can be interpreted according to the Hooke's equation. The test requires cutting a sample with a constant section area. If we assume that the shell thickness is constant the sample should be a parallel stripe of shell with a constant width.

This original method used in the determinations of rape seed shell resistance allows for avoiding the problem of sample fixing in the holders. It is possible thanks to the way the sample stripe is cut out from the shell for the tension test (see fig.1) and that consists in cutting out a disk from the seed that was prewetted up to the 25% m.c.

This level of seed moisture contents allows for a complete shell filling and its fit tightly to the spherical surface of the seed cotyledon and does not cause its initial stress at the same time. The seeds prepared in this way can be easily cut. Cutting the seed with two parallel blades in order to obviate the germ we get a disk; after two halves of the seed leaves are taken out we obtain a stripe of the shell in the shape of a band.

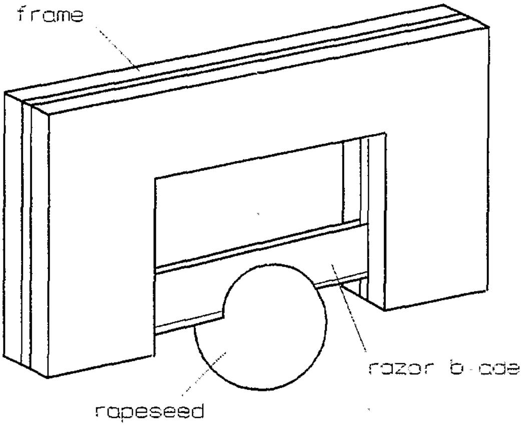

Fig. 1. The method of stripe cutting from the rapeseed shell.

The band was disrupt by means of two parallel cylinders (fig.2) in order to obtain a sample consisting of two parallel stripes of the shell. The initial length of the sample was recorded. Because of some thickening of the cover at the suture at its opposite positions, and the fact that no extension of these parts takes place during tensioning, they were placed on the cylinders and the length of the parallel parts equaling distance between the cylinders' axes was regarded as l.

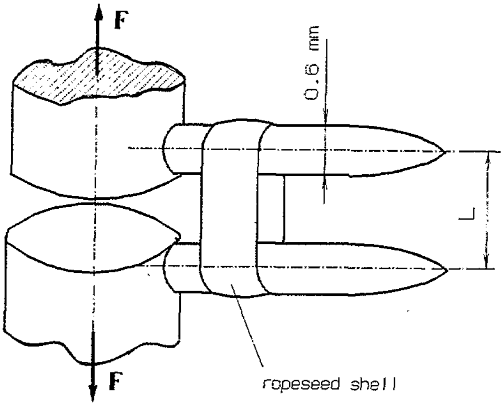

Fig. 2. Rapeseed shell in tension test.

The sample section area was determined as the area set out by the stripe length (1 mm) equal to the distance between the cutting blades and the cover thickness determined for all the studied moisture levels.

Determination of all the above mentioned values allows for calculating the tension stress and the modulus of elasticity of the seed shell on the basis of the Hooke's equation.

Small dimensions of the cover as well as its small weight and high rate of its drying, together with the tendency towards deformation at drying do not allow for using the methods of wetting usually used for seeds where we add an appropriate amount of water to the known seed mass in order to obtain the desired seed moisture contents.

Shell samples were placed in a little box made of wire-net and put into the hermetic moisture-conditioning bottle, in which earlier some rapeseeds were wetted to the required moisture content. When the shell samples achieved the adequate miosture content (after 24 hours), they were taken out for the experiments.

The tension tests were performed on the Instron machine model 1253. The sample was placed on two parallel steel hooks with the diameters of 0.6 mm. The deformation velocity was 5 mm/min, and the force-displacement curve was obtained for each sample. The characteristic parameters were read and modulus of elasticity was calculated.

It was not possible to measure the thickness of each of the studied shells because of the long time period necessary for tensioning one sample during which sample moisture contents underwent changes. Thickness measurement would lengthen this period even further. After tearing all the dimensions of the shell were changed by the deformation. That is why the characteristics of the changes in the shell thickness in relation to its moisture contents was determined, and a constant mean value of its thickness at different moisture levels was assumed.

RESULTS

Seed shell tensioning resistance tests were conducted on the three rape varieties: Ceres, Jupiter and Jantar according to the elaborated method. The method used allows for registering the force-displacement curve while tension a double shell stripe till it broke. The maximum values of the forces observed during shell rupture for all the studied varieties and moisture levels are presented in fig.3.

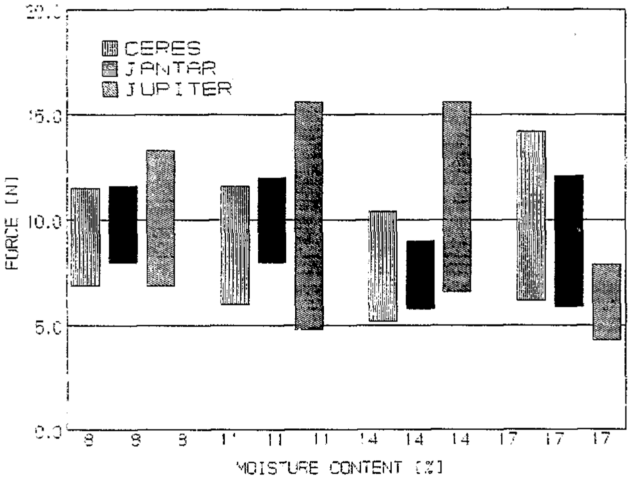

Fig.3. The forces observd during shell rupture.

The values obtained do not allow for distinguishing any of the studied varieties. However, a certain decreasing tendency was observed with the increase of moisture contents. Dispertion of the results that was found among the studied samples makes drawing any statistic conclusions impossible.

A similar situation was observed while the modulus of elasticity was determined on the basis of the force-deformation graph in the full range, i.e. till the shell got damaged. These values are also very differentiated in the case of individual samples (fig.4).

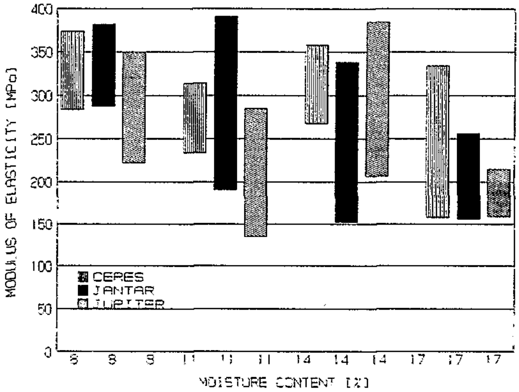

Fig.4. Modulus of elasticity in the range of the shell rupture.

It is probable that even when the differentiation in the thickness of the parallel shell stripes is small at large deformations one of the parts undergoes narrowing, and the test of stretching a double shell stripe changes into the tension test of a single stripe. This must influence the recorded value of the maximum force during the moment of shell damage as well as the value of the modulus of elasticity determined in this range of deformations. That is why the modulus of elasticity was determined in the range of elastic deformations in which neither parts of the shell underwent narrowing. It allowed for observing a definitely negative influence of the moisture contents on the values of the modulus of elasticity that decreased from 350 MPa to 157 MPa (Fig.5.).

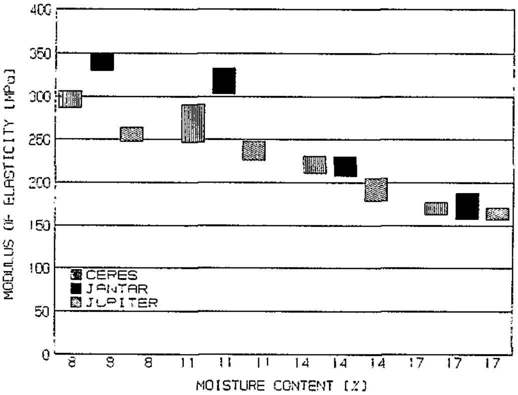

Fig.5. Modulus of elasticity in the range of elastic deformation.

Was also noticed that the rape shell of the Jantar variety was the strongest among the studied varieties, whereas var. Jupiter had the weakest shell seed from all the studied ones.

In the future it seems plausible to work out a detailed method of taking measurements of the shell thickness. That may eliminate the influence of shell thickness differences on the values of the modulus of elasticity of individual seeds.

CONCLUSIONS

1. The elaborated method of measuring the seed shell modulus of elasticity allows for the application of the tension tests in which the sample does not have to be fixed in the holders.
2. The scope of the method application cannot exceed the range of elastic deformations for which the interpretation of results is explicit.
3. The modulus of elasticity decreases with the increase of moisture contents in the range from 157-188 MPa (for the moisture level of 8%) to 248-350 MPa (for the moisture level of 17%).

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