Int. Agrophysics, 1994, 8, 231-234

INFLUENCE OF SOME MECHANICAL PROPERTIES OF SEED ON ENERGY REQUIREMENT FOR THEIR COMMINUTION

J. Grochowicz[1], *R. Nadulski*[1], *W.K. Bilanski*[2]

[1]Department of Food Engineering and Machinery, University of Agriculture
Doświadczalna 44, 20-236 Lublin, Poland
[2]School of Engineering, University of Guelph, N161W5 Guelph, Ontario, Canada

A b s t r a c t. The relationship between some strength properties of horse bean seeds and the energy required for comminution, expressed in unitary energy consumption was investigated.

K e y w o r d s: horse bean seeds, mechanical properties

INTRODUCTION

The aim of this research was to determine the relationship between some strength properties of horse bean seeds and the energy required for comminution, expressed in unitary energy consumption. The value of destructive forces were related to values of true strain for seeds of various moisture content exposed to crushing, cutting and penetrometrical tests. The influence of moisture content on unitary energy consumption during processing was also examined.

MATERIAL AND METHODOLOGY

To learn the changeability of the examined strength properties, seeds of relative homogeneity per variety were moistened and then divided according to thickness into size categories using a Vogel sifter with a set of sieves with oblong openings, to yield ten levels of moisture content within the range of 10 % to 24 %. Strength properties were measured with an INSTRON apparatus. In all cases seeds placed with their cotyledons parallel to the equipment base. Single seeds were crushed between two parallel plates (one lower immovable), loaded with steel cutting slat 1 mm wide. Penetration tests used a cylindric tester of 1 mm diameter. In all cases the loading element moved with a constant speed of 10 mm/min. The measurement was taken to the moment of seed destruction (cutting or piercing a cotyledon). From the force-displacement diagrams, the maximum destructive force was read and after calculation-true strain related to the force.

The process of comminution of seeds was realized on the measuring position consisted of a hammer mill, a plate batcher, a WATTREG power register and the container for ground grain. Seeds of eight different moisture contents ranging from 10 % to 20 % were comminuted at the full loading of the hammer mill. Hence, knowing the capacity and the energy consumption during the measuring cycle, the unitary energy consumption during the processing was calculated.

THE RESULTS AND ANALYSIS

The results of the experiments were analyzed statistically using the following methods: analysis of variance (to evaluate the influence of seed variety on the examined properties) and analysis of regression.

Figure 1 shows the range of changeability of examined parameters at different levels of moisture content.

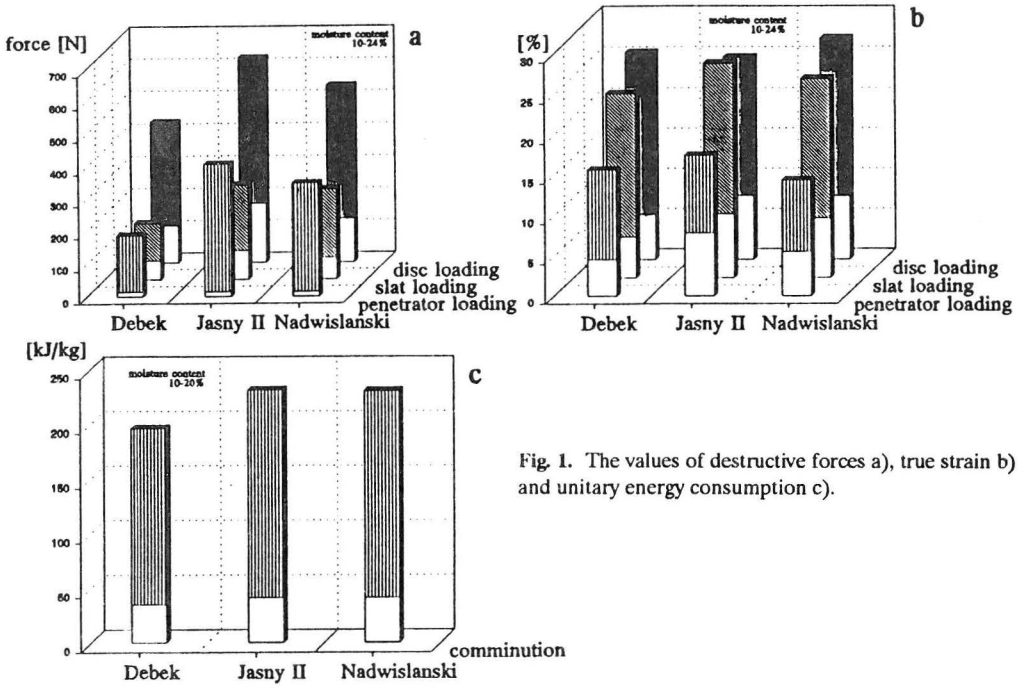

Fig. 1. The values of destructive forces a), true strain b) and unitary energy consumption c).

The analysis of variance did not show the influence of variety features on the appointed parameters in the examined ranges of moisture content.

Figure 2 relates force applied to seed moisture content. In all cases the increase of moisture content cause the significant gradual decrease of the values of destructive forces. In the case of crushing, cutting and penetration the maximal forces are several times bigger than the minimal ones. Influence of moisture content on destructive forces of the seeds crushed between two plates and tested with penetrometer, had been described by the regression equation in the form of parabola, but for the cut seeds - by the linear equation.

Figure 3 demonstrates the dependence of true strains corresponding with destructive forces on the moisture content of seeds. The increase of moisture content of seeds cause the apparent gradual increase of the value of true strains. The maximum values are in all cases several times greater than minimum ones. The dependencies of true strains on the moisture content of seeds are described with equations of parabola.

For the regression equations describing the dependencies of destructive forces and true strains on the moisture content of seeds, the high values of correlation coefficients had been achieved.

Figure 4 shows the dependence of unitary energy consumption of the moisture content of seeds. In the analyzed range of moisture content the maximum values are about six times greater than minimum ones. The dependence of unitary energy consumption on the moisture content of seeds had been described with regression equa-

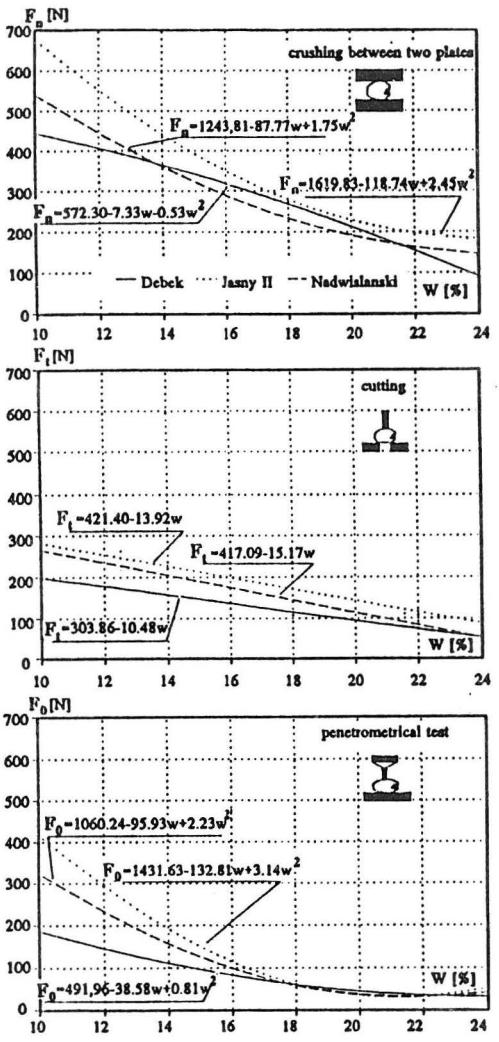

Fig. 2. The course of the interdependence force-moisture content for the seeds (W-moisture content, F_n, F_t and F_o - force for three types of loading).

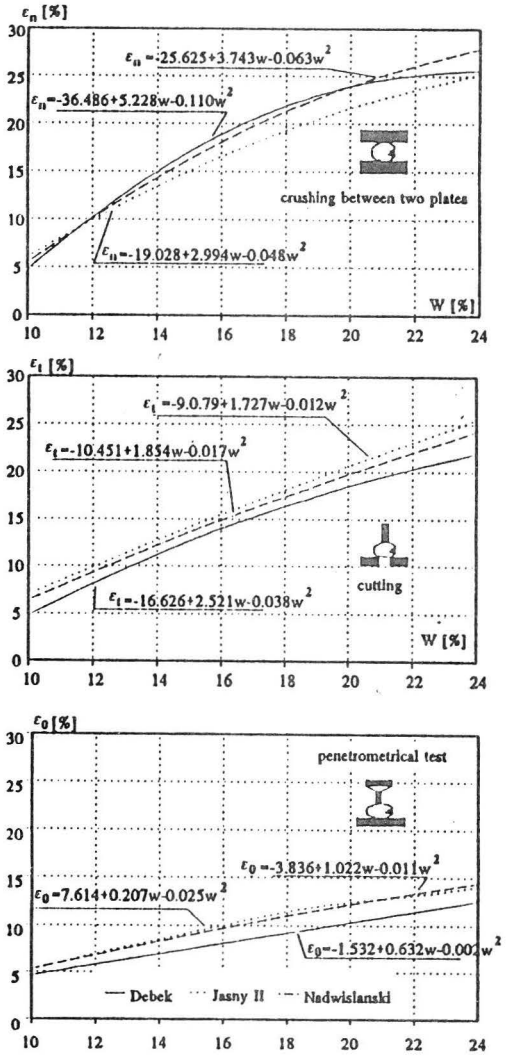

Fig. 3. The course of the interdependence true strain-moisture content for the seeds (W-moisture content, ε, ε_n, ε_t and ε_n - true strain for three types of loading).

Table 1. The values of correlation coefficients between the strength properties and unitary energy consumption in the comminution for three varieties of horse bean seeds

No.	Parameter	Type of loading	Value of correlation coefficients of variety		
			Dębek	Jasny II	Nadwiślański
1	Force	disc loading	-0.8681	-0.9875	-0.9697
2	True strain	disc loading	0.9355	0.9908	0.9889
3	Force	slat loading	-0.9124	-0.9806	-0.9782
4	True strain	slat loading	0.9307	0.9686	0.9886
5	Force	penetrator loading	-0.9182	-0.9346	-0.9011
6	True strain	penetrator loading	0.9453	0.9754	0.9886

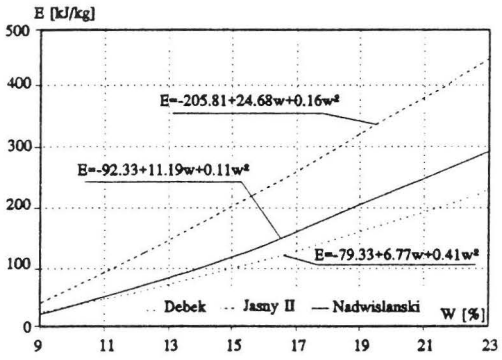

Fig. 4. The course of the dependence of unitary energy consumption of moisture content for the seeds (E - energy consumption, W - moisture content).

tions in the form of parabola. The increase of the moisture content of seeds causes considerable increase of unitary energy consumption. With the exceeding 20 % moisture content of seeds, the increase of the value of unitary energy consumption was so high that it caused the overloading of the engine of a hammer mill. At the some time it had been found, that seeds were ground very poorly, and therefore the further measurements above that value of the moisture content were not taken.

In Table 1 the values of correlation coefficients between the examined strength properties and unitary energy consumption had been set up. In all cases the high values of correlation coefficients had been found. It points to the significant difference between the analyzed values. A bit lower values of correlation coefficients in comparison to other varieties have been got for the seeds of variety Dębek. From the experiments it turned out that on the basis of the chosen strength properties of seeds it is possible to state about their susceptibility for comminution and to evaluate the energy consumption of the process.

CONCLUSION

From the test performed the following conclusions may be drawn:

1. The increase of moisture content of seeds causes the apparent decrease of the values of destructive forces. The dependence of the values of destructive forces on the moisture content of seeds had been described with regression equation in parabola form for the seeds crushed between two plates and exposed to penetrometric test and with regression equation for the cut seeds.

2. The increase of the moisture content of seeds causes gradual increase of the values of true strains. The dependence of value of true strains on moisture content had been described in all cases with regression equations in a parabolic form.

3. As seed moisture content increases more energy for comminution is required. The dependence of unitary energy consumption on the moisture content of seeds in the range of moisture content (10-20 %) has been presented in parabolic form.

4. Between the analyzed strength properties and unitary energy consumption the strong interdependence is evident, which is expressed by the high values of regression coefficients. On the basis of knowledge of strength properties it is possible to state about the seeds susceptibility for comminution and energy consumption of that process.

REFERENCES

1. **Bilanski W.K.:** Damage resistance of seed grains. Trans ASAE, 9, 3, 360-363, 1966.
2. **Grochowicz J., Nadulski R.:** The investigation of some mechanical properties of horse bean seeds. Zesz. Probl. Post. Nauk Roln., 354, 67-71, 1989.
3. **Grochowicz J., Nadulski R.:** The mechanical properties of some leguminous plant seeds. In Reźnicek R. (ed.): Physical Properties of Agricultural Materials and Products. University of Agriculture, Prague, Czechoslovakia, Hemisphere Publishing Corporation. A subsidiary of Horper and Pow Publisher, Inc. Washington, New York, London, 453-456, 1988.
4. **Grochowicz J., Nadulski R.:** Untersuchungen über Die Bedingungen Des Samenschnittes Als Beurteilungskriterium Der Zerkleinerungsfähigkeit Des Samengutes. Proceedings: 3, Wissenschaftlichen Tagung Agrophysik, Schloss Reinhardsburnn, GDR, 400-403, 1989.
5. **Mohsenin N.N.:** Physical of Engineering of Plant and Animal Materials. Gordon and Breach Science Publ., New York, 1970.