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SOME PHYSICAL PROPERTIES OF SPELT WHEAT SEED

Mariusz Szymanek [*], Paweł Sobczak [**]

[*] Department of Agricultural Machines Science, University of Life Sciences in Lublin
[**] *Department* of Food Engineering and Machinery, University of Life Sciences in Lublin, Gleboka 28, 20-612 Lublin, Corresponding author's e-mail: mariusz.szymanek@up.lublin.pl

Abstract. The objective of this study was to investigate the effect of moisture content on some physical properties of two kinds of the spelt wheat seed (with and without chaff). The average length, width and thickness were 5.89 mm, 3.21 and 2.51 mm for seeds without chaff and 9.47 mm, 3.53 mm and 2.62 mm for seeds with chaff. The study showed that the change of moisture content in the range from 8.1 to 24.3% caused both for the seeds with and without chaff the increase of 50% and 61% for coefficient friction, 45% and 43% for thousand seeds weight and the decrease of 4% and 2% for uncompacted bulk density, 8% and 3% for compacted bulk density, 40% and 14% for compression force, 12% and 49% for deformation, 24% and 51% for modulus of elasticity.

Key words: spelt wheat seeds, physical properties, moisture content.

1. INTRODUCTION

Spelt wheat (Triticum aestivum subsp. spelta) is an old European crop, grown for centuries, including the first half of this century, in several countries of Europe. For many years cultivation of spelt declined, but recent interest in use of spelt for ecologically grown foods has led to resurgence in its cultivation. Spelt wheat is a low-input plant, suitable for growing without the use of pesticides, in harsh ecological conditions and in marginal areas of cultivation (Bonafaccia et al., 2006).

In 2002 in Poland a project started to be realized concerning restoration of old cereals growing. Actually, the area of growing spelt in Europe involves ca 18, 000 ha and in Poland ca 250 ha (Sulewska, 2006). The interest in growing spelt in Poland has been increasing year by year and is mainly concentrated in ecological farms.

The seeds of spelt contain peck of protein, cellulose, non – saturated fatty acid, carbohydrate, vitamin and chemical elements (Grela, 2006; Ranhotra, 1996a , 1996b).

The physical properties of biological substances produced by agriculture have been an object of scientific interest since long ago. The growing mechanization level in agriculture and food processing creates the need for this kind of knowledge. It is indispensable, since constructors are creating more and more aggressively working machines and devices causing higher and higher losses percentage of the produced yield and raw materials used in the production process (Haman and Konstankiewicz, 1999).

Several investigators determined the physical properties of seeds at various moisture contents such as Shepherd and Bhardwaj (1986) for pigeon pea, Vilche et al. (2003) for quinoa seeds, Ogunjimi et al. (2002) for locust bean seed, Konak et al. (2002) for chickpea seeds. However, no published work seems to have been carried out on the physical properties of spelt wheat seed and their relationship with moisture content. Hence, this study was conducted to investigate some moisture dependent physical properties of spelt wheat seed such as geometrical size, coefficient friction, bulk density, thousand seed weight, compression force, deformation and modulus of elasticity.

2. MATERIAL AND METHODS

The spelt seeds cultivar Schwabenkorn used in the present study were obtained from a crop grown during 2007 in Poland. The seeds were mechanically and manually cleaned to remove all foreign matter or broken seeds. The studies were carried out for two kinds of spelt seed: with and without chaff (Fig. 1).

a) b)

Fig. 1. The spelt wheat seeds: a) without chaff, b) with chaff

The initial moisture content of the seeds was determined by the vacuum oven method moisture (PN-ISO 6540, 1994). The initial moisture content of the spelt seeds was 16,2 % (d.b.). The samples of the desired moisture contents were prepared by drying or adding the amount of distilled water as calculated from the following relation (Sacilik et al., 2003).

$$Q = \frac{m_i (M_f - M_i)}{100 - M_f}. \tag{1}$$

According to Özarslan (2002) the samples were then poured into separate polyethylene bags and the bags sealed tightly. The samples were kept at 5ºC in a refrigerator for a week to enable the moisture to distribute uniformly throughout the sample. Before starting a test, the required quantity of the seed was taken out of the refrigerator and allowed to equilibrate to the room temperature for about 2 h.

All the physical properties of the spelt seed were determined at moisture contents in the range from 8.1 to 24.3% d.b. with 6 replications at each moisture level. The data were statistically analysed by variance analysis to determine significant differences among samples using Statistica 6.0. PL. The significance was assumed at $p<0.05$.

To determine the physical properties of spelt seed the standard methods were used according to Mohsenin (1968) and AOAC (1980). The static coefficient was determined on stainless steel. The average dimension of 100 seeds were measured at a moisture content of 8.10% by using an electronic caliper with 0.03 mm accuracy.

Spelt seeds were subject to compression on the universal testing machine Instron 6022. The seeds were compressed between two flat parallel plates at a crosshead speed 50 mm·min^{-1} and load of 100 N. The compression test determined the force, deformation and modulus of elasticity.

3. RESULTS AND DISCUSSION

The average dimensions of spelt seeds without and with chaff and their ratio are presented in Tab. 1.

Table 1. The dimensions of seeds

Seeds	Average length, mm	Average width, mm	Average thick-ness, mm	Average length/ width ratio	Average length/ thickness ratio
without chaff	5.89	3.21	2.51	1.83	2.34
with chaff	9.47	3.53	2.62	2.68	3.61

The average dimensions of seeds with chaff in relation to seeds without chaff were higher about 38% for length, about 9% for width and about 4% for thickness. The static coefficients of friction of spelt seed on metal surfaces against moisture content in the range 8.1–24.3% d.b. are presented in Fig. 2. and Fig. 3.

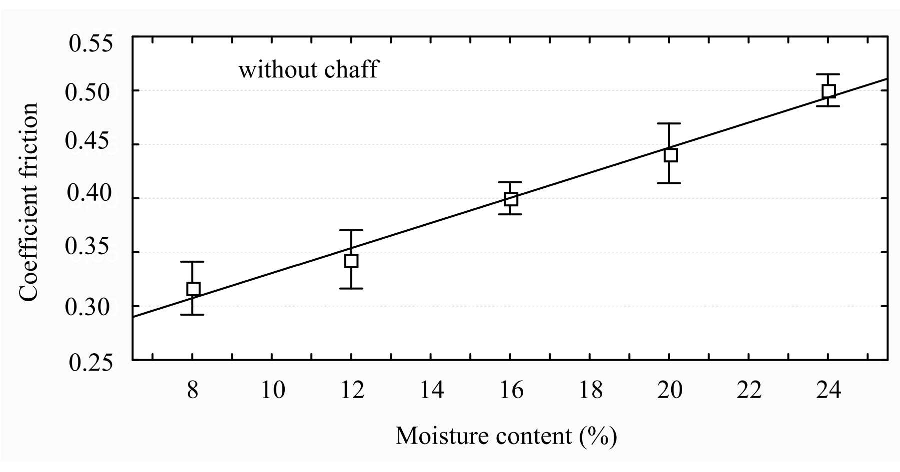

Fig. 2. Effect of moisture content on the friction coefficient of seed without chaff

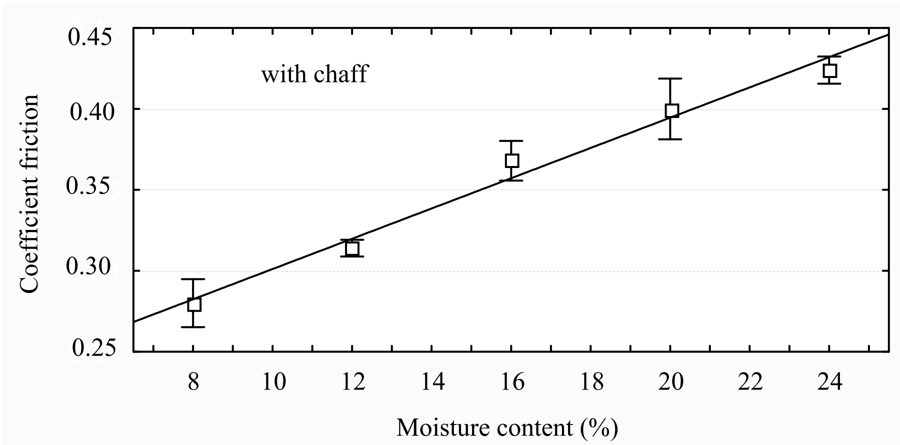

Fig. 3. Effect of moisture content on the friction coefficient of seed with chaff

It was observed that the static coefficient of friction increased with an increase in moisture content from 8.1 to 24.3% for the seeds of both kinds. Increases in the range from 28.0 to 42.4% (with chaff) and from 31.7 to 50.0% (without chaff) were recorded. At all moisture contents, the largest static coefficient of friction was for seeds without chaff.

The relationships between static coefficients of friction and moisture content can be represented by the following equations:

for spelt seeds with chaff $$\mu = 0.0093 M_c + 0.8076 \quad (R^2 = 0.9414), \tag{2}$$

for spelt seeds without chaff $$\mu = 0.0116 M_c + 0.2142 \quad (R^2 = 0.9097). \tag{3}$$

Figure 4 and 5 shows the effect of moisture content on uncompacted bulk density of spelt seed with and without chaff.

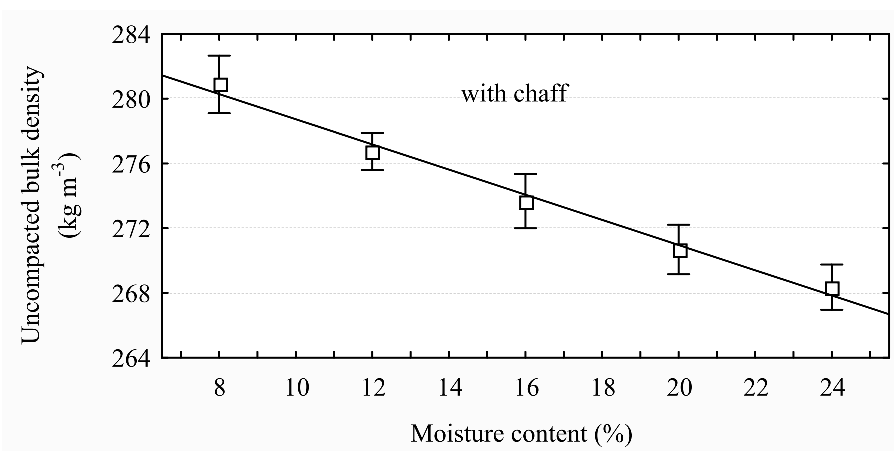

Fig. 4. Effect of moisture content on uncompacted bulk density of seed with chaff

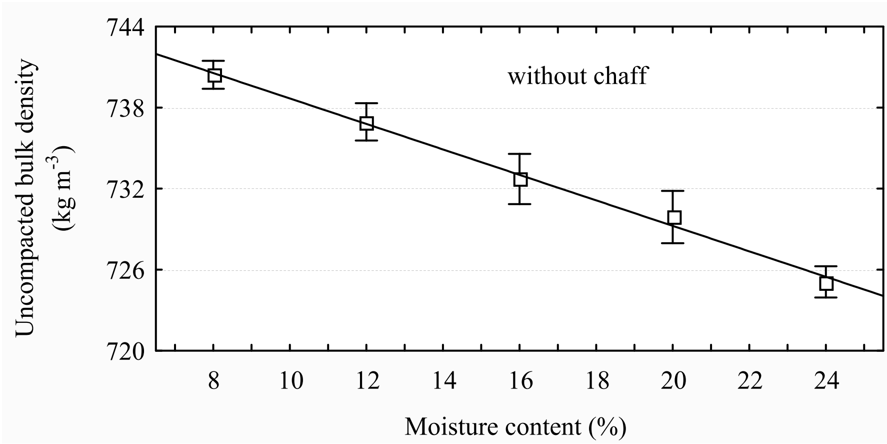

Fig. 5. Effect of moisture content on uncompacted bulk density of seed without chaff

The values of the uncompacted bulk density of two kinds of seeds for different moisture levels varied from 268.6 to 280.8 kg·m^{-3} for seeds with chaff and from 725.9 to 740.3 kg·m^{-3} for seeds without chaff. The uncompacted bulk density of spelt seeds is characterized by the following relationship with moisture content:

for spelt seeds with chaff $$\rho_u = -0.9431 M_c + 748.1083 \quad (R^2 = 0.9380), \tag{4}$$

for spelt seeds without chaff $$\rho_u = -0.7774 M_c + 286.5033 \quad (R^2 = 0.9079). \tag{5}$$

The uncompacted bulk density decreased with an increase in moisture content. Similar trends were recorded for compacted bulk density (Fig. 6 and 7).

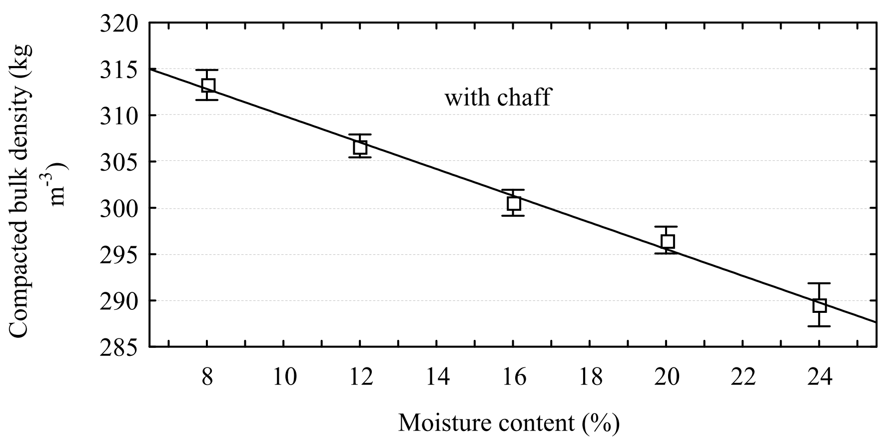

Fig. 6. Effect of moisture content on compacted bulk density of seeds with chaff

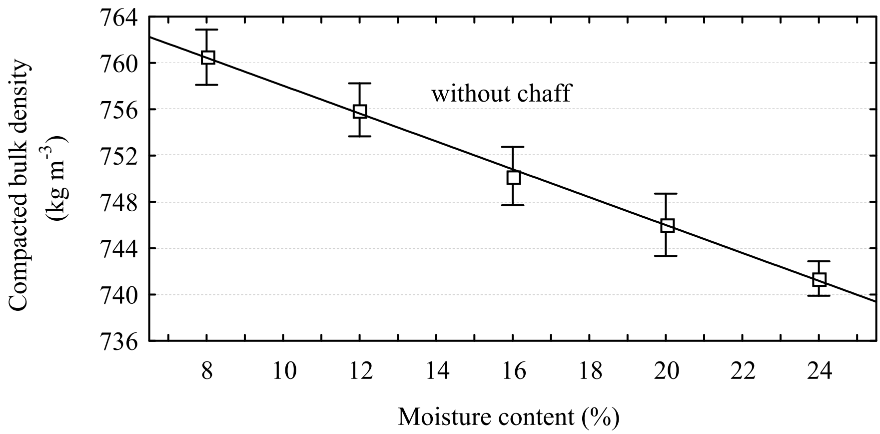

Fig. 7. Effect of moisture content on compacted bulk density of seeds without chaff

The compacted bulk density was found to decrease linearly in moisture content from 313.26 to 289.53 kg·m^{-3} for seeds with chaff and from 760.50 to 741.38 kg·m^{-3} for seeds without chaff. The variation in compacted bulk density with moisture content can be represented by the following equation:

for spelt seeds with chaff $\rho_C = -1.4408M_c + 324.3633 \quad (R^2 = 0.9645),$ (6)

for spelt seeds without chaff $\rho_C = -1.2042M_c + 770.0833 \quad (R^2 = 0.9180).$ (7)

Figure 8 and 9 shows the effect of moisture content on 1000 seeds weight of spelt seeds.

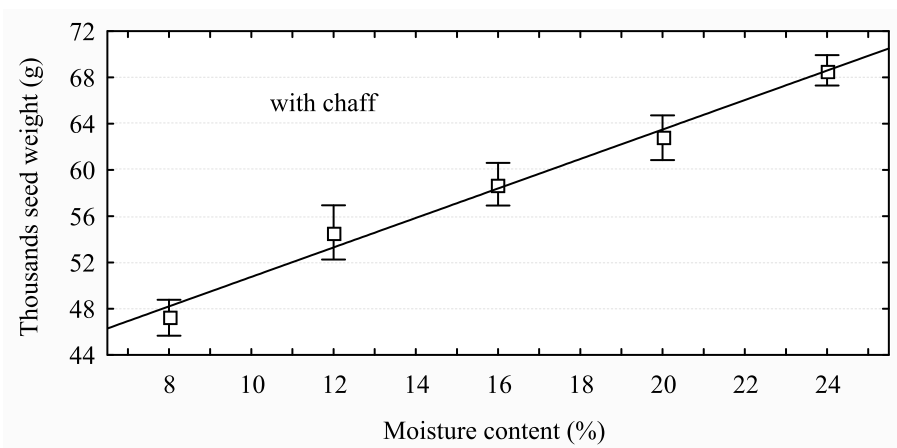

Fig. 8. Effect of moisture content on 1000 seeds weight of seed with chaff

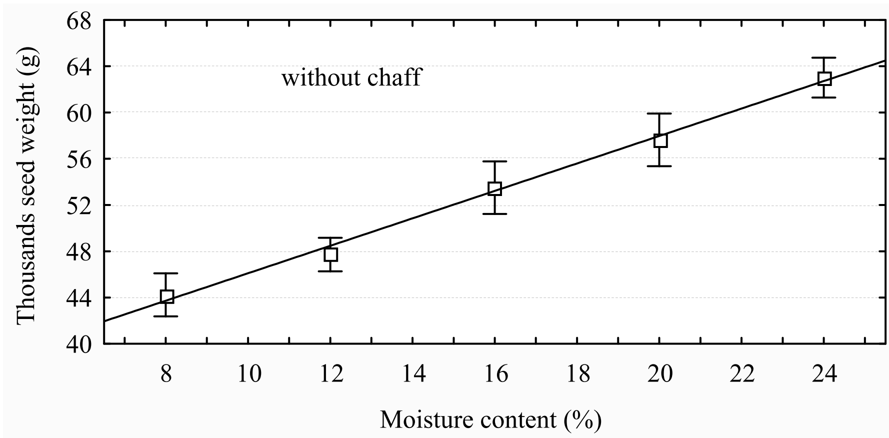

Fig. 9. Effect of moisture content on 1000 seeds weight of seed without chaff

A 1000 seeds weight was found to increase linearly with moisture content from 47.21 to 68.61 g for seeds with chaff and from 44.23 to 63.01 g for seeds without chaff. A linear relationship between 1000 seeds weight and moisture content can be expressed using the regression equation:

for spelt seeds with chaff $m_{1000} = 1.2746M_c + 38.0033 \quad (R^2 = 0.8918)$, (8)

for spelt seeds without chaff $m_{1000} = 1.871M_c + 34.2267 \quad (R^2 = 0.8224)$. (9)

Similar trends were reported for both kinds of spelt seeds.

The compression forces of spelt seeds are presented in Fig. 10 and 11.

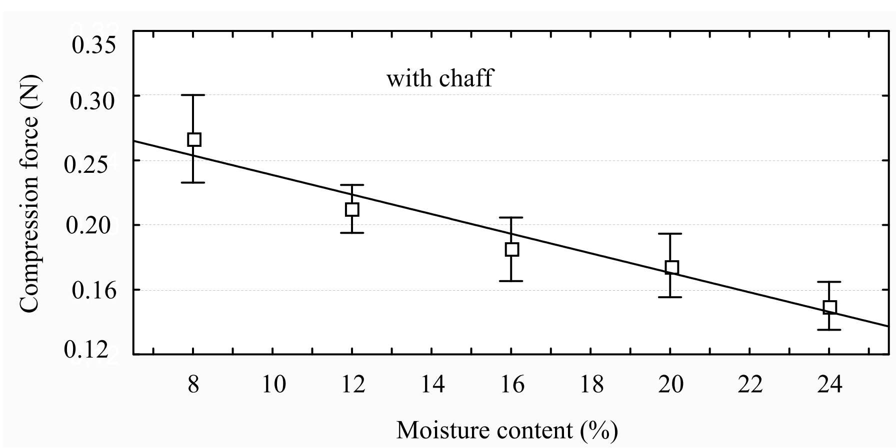

Fig. 10. Effect of moisture content on compression force of seeds with chaff

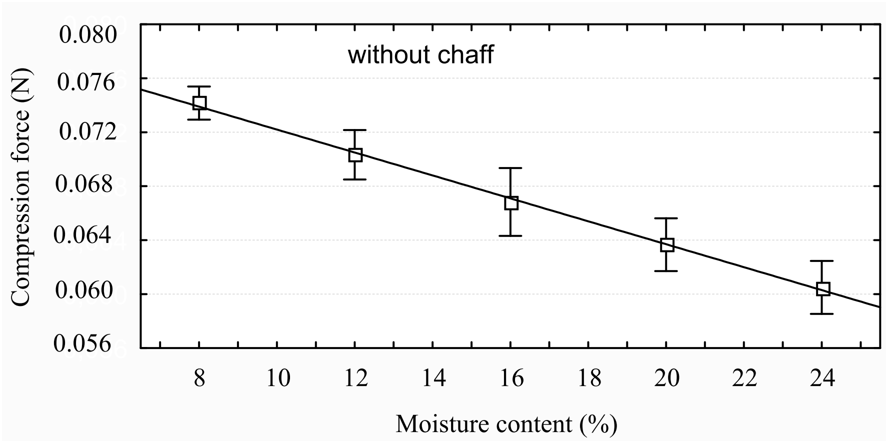

Fig. 11. Effect of moisture content on compression force of seeds without chaff

The compression force can be presented by the following equation:

for spelt seeds with chaff $$F = -0.006M_c + 0.2913 \quad (R^2 = 0.7659), \tag{10}$$

for spelt seeds without chaff $$F = -0.0009M_c + 0.0807 \quad (R^2 = 0.8884). \tag{11}$$

The compression force was found to decrease linearly in moisture content from 0.2533 to 0.1501 N for spelt seeds with chaff and from 0.074 to 0.061 N for spelt seeds without chaff.

The Fig. 12 and 13 shows the linear dependence of deformation.

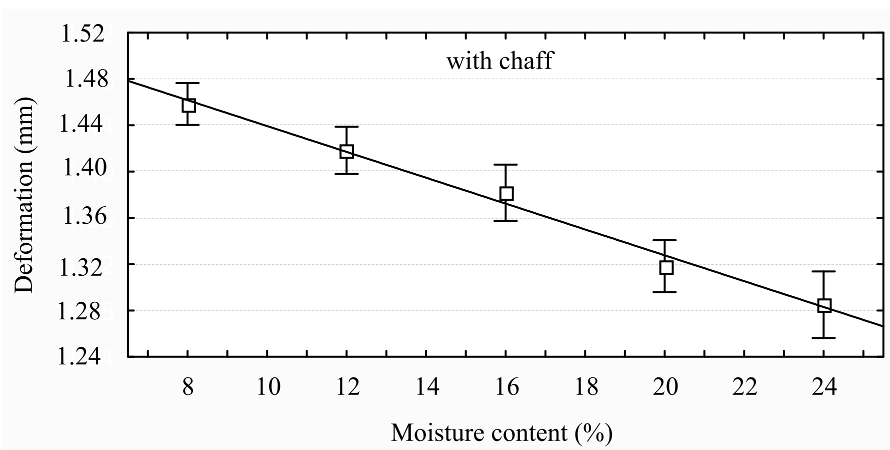

Fig. 12. Effect of moisture content on deformation of seeds with chaff

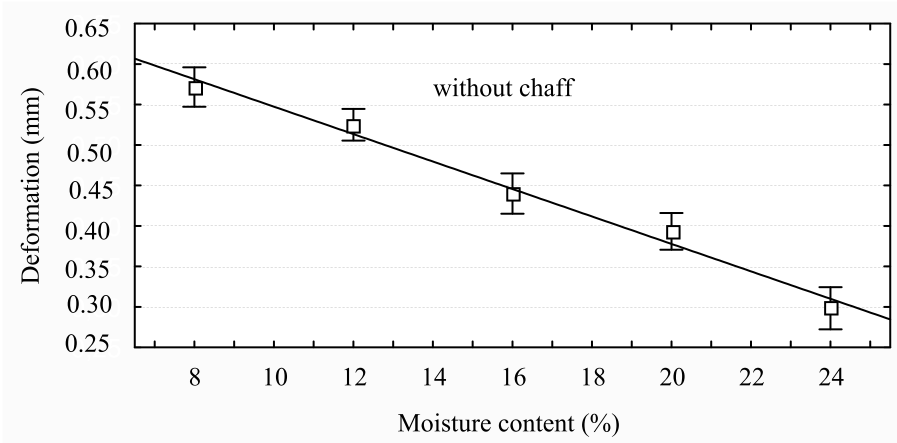

Fig. 13. Effect of moisture content on deformation of seeds without chaff

The deformation values decreased with an increase in moisture content for both kinds of seeds.

The experimentally observed data on the deformation at a moisture content can be represented by the following regression equation:

for spelt seeds with chaff $D = -0.0112M_c + 1.5510 \quad (R^2 = 0.9004),$ (12)

for spelt seeds without chaff $D = -0.0171M_c + 0.7172(R^2 = 0.9437).$ (13)

The deformation values decreased linearly from 1.45 to 1.28 mm for spelt seeds with chaff and from 0.57 to 0.29 mm from spelt seeds without chaff. The modulus of elasticity of the spelt seeds decreased from 46.03 to 35.18 MPa for seeds with chaff (Fig. 14) and from 20.60 to 10.11 MPa for seeds without chaff (Fig. 15).

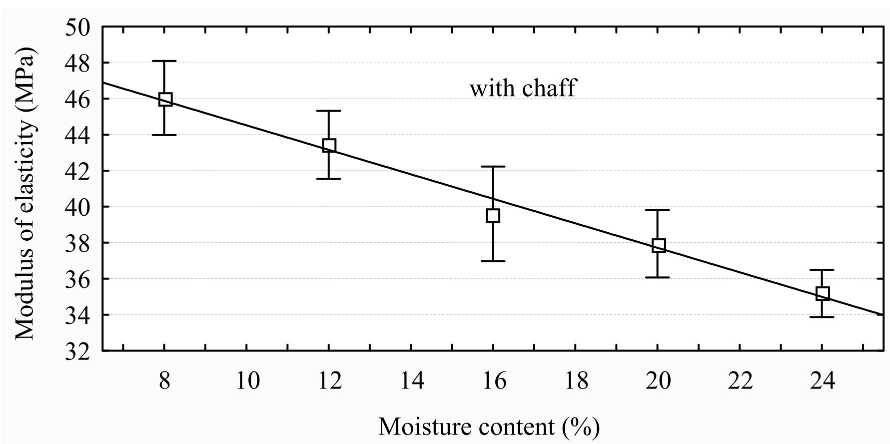

Fig. 14. Effect of moisture content on modulus of elasticity of seeds with chaff

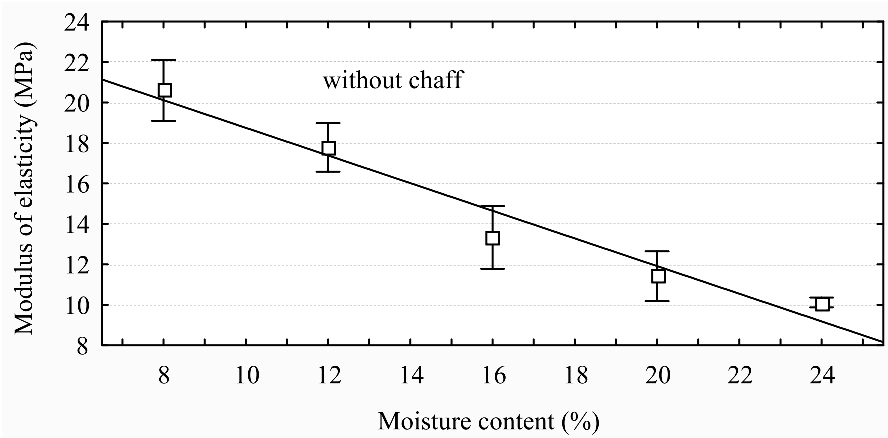

Fig. 15. Effect of moisture content on modulus of elasticity of seeds without chaff

The linear equation for modulus of elasticity can be formulated to be:

for spelt seeds with chaff $$M = -0.6814M_c + 51.3167 \quad (R^2 = 0.8224), \tag{14}$$

for spelt seeds without chaff $$M = -0.8918M_c + 25.5833(R^2 = 0.8918). \tag{15}$$

4. CONCLUSIONS

The investigations of some physical properties of two kind of spelt wheat seeds in a range of moisture content were carried out. As the moisture content increased, the mean values of coefficient friction and thousands seeds weight increased and bulk density, compression force, deformation and modulus of elasticity decreased. In the analyzed range of moisture content there were observed for spelt seeds with and without chaff the respective changes of about 50% and 61% for coefficient friction, 4% and 2% for uncompacted bulk density, 8% and 3% for compacted bulk density, 45% and 43% for thousand seeds weight, 40% and 14% for compression force, 12% and 49% for deformation, 24% and 51% for modulus of elasticity.

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WYBRANE WŁAŚCIWOŚCI FIZYCZNE NASION PSZENICY ORKISZOWEJ

Streszczenie. Celem pracy było określenie wpływu wilgotności nasion nieoplewionych i oplewinych pszenicy orkiszowej na wybrane ich właściwości fizyczne. Średnia długość, szerokość i grubość wynosiła odpowiednio 5,89 mm; 3,21 i 2,51 mm dla nasion nieoplewinych i 9,47 mm; 3,53 mm i 2,62 mm dla nasion oplewionych. Badania wykazały, że zmiana wilgotności od 8,1 do 24,3%, odpowiednio dla nasion nieoplewionych i oplewionych, powodowała wzrost współczynnika tarcia 50 i 61% i masy 1000 nasion o 45 i 43% oraz spadek gęstości usypowej o 4 i 2%, gęstości utrzęsionej o 8 i 3%, siły ściskania o 40% i 14%, deformacji o 12 i 49% oraz modułu sprężystości o 24 i 51%.

Słowa kluczowe: pszenica orkiszowa, właściwości fizyczne, wilgotność