CHANGES IN RELATIVE PERMITTIVITY AND CHEMICAL COMPOSITION OF SOME GRAINS AND SEEDS DURING STORAGE

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The measurements were done on the wheat grains mixture removed from the purchase corporation in Rybany and oil seeds from Hontianske Nemce during storage. Moisture content was determined according to standards. Electrical properties were measured at various frequencies after various time of storage in silo. The capacitance and relative permittivity decrease with frequency powerly. Results showed that specific changes occurred in quality of all wheat grains components – proteinic profile and saccharide complex. Relative permittivity decreases with storage time according to quadratic function. Similarly for the crude protein and starch content and that is why a correlation exists between changes in relative permittivity and in crude protein and starch content during storage. A correlation between the changes in relative permittivity and wet gluten content and crude fibrous material respectively do not exist. It was impossible to create the time dependencies for oil-seeds because of short storage time.

INTRODUCTION

The temperature and moisture content have important role at the selection of suitable regime of the storage. These are the most important parameters that influence physical and physiological processes which run in the stored plant products. The temperature and moisture content affect quality of stored material and economy of storage.
Biological materials have limited durability in general. Their vegetability depends on the properties of surrounding environs and on the conditions

of the storage. Majority of the agricultural products are in the unstable or metastable states. Decrease of the stability during ageing is caused by these processes: sedimentation in biological liquids, mechanical deterioration, influence of water, temperature and radiation, transport of heat and humidity, metabolic processes, respiration, destructive processes caused by micro-organism and so on (Blahovec, 1993). Electrical properties of grains and seeds are changing during their storage and that is why we should use them at the determination of examined material various characteristics (Hlaváčová and Muchová, 2005). They are used at the indication of moisture contents during storage to keep it on optimal value, for example Lepack (1998) used measurement of the resistance in potato storage, Gordeev (1998) used electrical properties at the detection of occurrence of sound, diseased and damaged fruit for different storage periods.

MATERIAL AND METHODS

The measurements were done on the rape oil-seeds *Brassica napus,* L. and common sunflower seeds *Helianthus annus,* L. removed from the large-capacity steel store in Hontianske Nemce and wheat grains mixture *Triticum aestivum* L. from the concrete silo with active ventilation in purchase corporation in Rybany during storage. The system of active ventilation starts in dependence on external temperature, on humidity of air and on moisture of the stored grains or seeds which were measured within silo. Terms of the wheat grains removing: July 17, 2003 at the storage beginning, September 12, November 11, February 2, 2004, May 7 and August 23 at storage finishing. The time of oil seeds storing was short because of material absence which was caused by a low crop. Terms of the rape oil seeds removing: July 10, September 12, 2003. Terms of sunflower seeds removing: October 20, December 4, 2003, April 27, 2004. Average samples were removed from the operating boxes. Moisture content was determined according to standards ISO 712 and ISO 665. Average bulk density of the wheat grains was 786 $kg.m^{-3}$, for rape seeds 633 $kg.m^{-3}$ and sunflower seeds 411 $kg.m^{-3}$. The samples of grains and seeds were placed in the sensor with parameters: diameter of electrode 37.8 mm, electrodes spacing 49.2 mm, mass of empty sensor 208.89 g.
Electrical capacitance and loss factor were measured by LCR meter GoodWill LCR-819 at frequencies of 100 Hz, 500 Hz, 1 kHz, 3 kHz, 10

kHz, 50 kHz and 100 kHz after various time of storage in silo. The samples were granular material that means a mixture of grains and air. The permittivity of this type of the material can be described by equation of Thakur and Holmes (2001)

$$e^{\alpha \varepsilon_{eff}} = v_1 e^{\alpha \varepsilon_1} + (1 - v_1) e^{\alpha \varepsilon_2}$$

where: ε_1 – relative permitivity of grains, ε_2 – relative permitivity of air, ε_{eff} – relative permitivity of their mixture, v_1 – volume fraction of the grains, α - constant.

The chemical composition of long-term stored wheat grains was changing too. We measured the crude protein content, wet gluten content, starch content, falling number (for indirect determination of α-amylases activities) and crude fibrous material (created especially by cellulose, by fraction of hemicelluloses and lignin) content in wheat grains according to standards. The content of fatty acids especially linolenic acid and oleic acid was monitored by chromatographic method.

RESULTS AND DISCUSSION

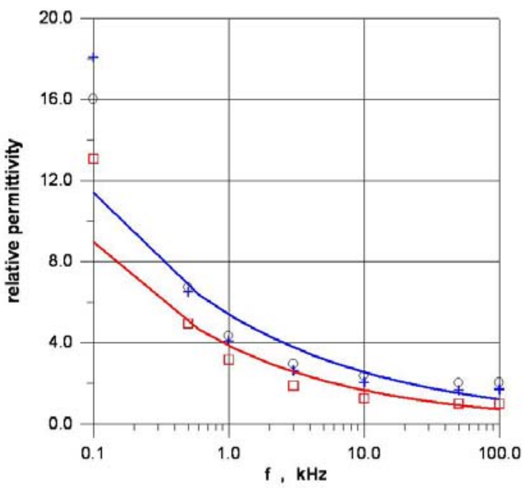

Fig. 1: The frequency dependencies of relative permittivity for sunflower seeds in terms - at moisture content - at oleic acid content
1) October 20, 2003 – 5.08 % – 30.705 % (o),

2) December 4, 2003 – 5.55 % – 32.348 % (+),
3) February 27, 2004 – 5.02 % – 30.470 % (□)

Frequency dependencies of electrical capacitance, loss factor and relative permittivity were determined for all samples of grains and seeds at several times of storage. The capacitance has lower values at all frequencies after longer time of storage and also at lower moisture content and oleic acid content. The capacitance with frequency decreases powerly. In Fig. 1 the frequency dependencies of the relative permittivity for sunflower seeds at moisture content of 5.08 %, 5.55 % and 5.02 % are shown. The relative permittivity has lower values at all frequencies after longer storage and also at lower moisture content and oleic acid content.
The relative permittivity with frequency decreases powerly and the regression equation is

$$\varepsilon_r = \varepsilon_{r1}\left(\frac{f}{f_1}\right)^{-k} \qquad (1)$$

where: ε_r – relative permittivity, ε_{r1} – relative permittivity at the reference frequency, f – frequency, f_1 = 1 kHz, k – constant. Regression equation has high coefficients of determination for all samples. Regression equation for the capacitance has similar shape. All dependencies have the same character. The chemical composition of long-term stored wheat grains was changing too.

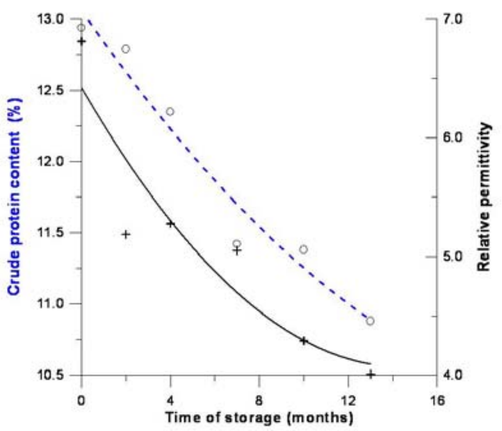

Fig. 2: Changes in crude protein content (o) and in relative permittivity (+) during the storage for wheat grains at frequency of 3 kHz

Tab. 1: Changes of wheat grains some chemical components

Date	**Moisture content %**	**Wet gluten %**	**Crude protein %**
17. 7. 03	11.85	26.19	12.94
12. 9. 03	11.63	26.30	12.79
11. 11. 03	13.20	26.10	12.35
27. 2. 04	13.05	23.85	11.42
7. 5. 04	12.85	23.44	11.38
23. 8. 04	12.00	20.16	10.88

Date	**Falling number s**	**Starch %**	**Crude fibrous material %**
17. 7. 03	347	67.43	2.86
12. 9. 03	349	66.26	2.82
11. 11. 03	276	64.63	2.80
27. 2. 04	350	63.95	3.35
7. 5. 04	370	63.26	2.87
23. 8. 04	350	63.15	2.73

The correlation between changes in electrical properties and in chemical composition was searched. For illustration, in Fig. 2 changes in crude protein content and in relative permittivity are shown.
These dependencies can be approximated by regression equation in the shape

$$\varepsilon_r = k_o + k_1 \frac{t}{t_1} + k_2 \left(\frac{t}{t_1} \right)^2 \qquad (2)$$

where: k_o, k_1, k_2 – coefficients of regression equation, t – time of storage and t_1 = 1 month.

Coefficients of determination have high values. The relative permittivity decreases with storage time according to quadratic function. The crude protein content and starch content decrease with storage time according to quadratic function too and that is why exists a correlation between changes in relative permittivity and in crude protein content and in starch content during storage.

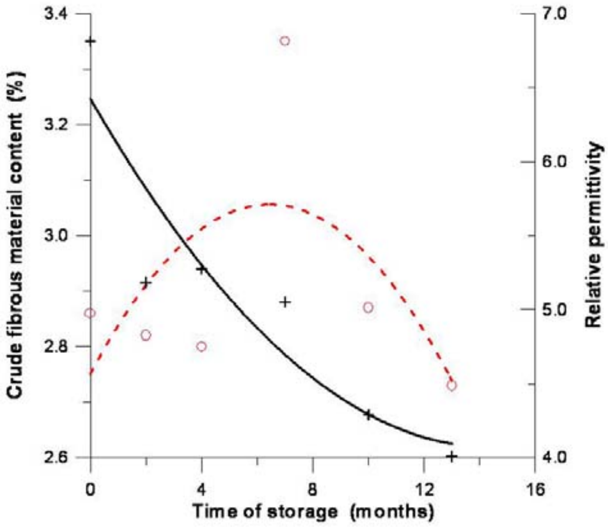

Fig. 3: Changes in crude fibrous material content (o) and in relative permittivity (+) measured at frequency of 3 kHz during storage

Between the changes in relative permittivity and the wet gluten content, crude fibrous material content (Fig. 3) and respectively falling number a correlation do not exists.

The stability of fat component is important in stored oil-seeds and it is longer at higher content of the oleic acid. The changes in content of fatty acids which could influence technological quality of oil-seeds were not occurred during storage.

CONCLUSION

The temperature and moisture content affect quality of stored material and economy of storage. Electrical properties of grains and seeds are changing during their storage and that is why we should use them at the determination of examined material various characteristics.

The capacitance and relative permittivity decrease powerly with frequency according to Eq. 1. Results showed that specific changes occurred in quality of all wheat grains components – proteinic profile and saccharide complex during 13 months of holding and under condition of active ventilation too. The relative permittivity decreases with storage time according to quadratic function (Eq. 2). The crude protein content and starch content decrease with storage time according to quadratic function too and that is why a correlation exists between changes in relative permittivity and in crude protein content and in starch content during storage. Between the changes in relative permittivity and the wet gluten content, crude fibrous material content and falling number respectively a correlation do not exists. It was impossible to create the time dependencies for oil-seeds because of short time of storage. The changes in content of fatty acids which could influence technological quality of oil-seeds were not occurred during the storage.

It is usually necessary to measure the electrical properties under the particular conditions of interest to obtain reliable data.

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