Influence of Relative Humidity and Temperature on the Changes in Grain Moisture in Stored Soybean and Maize

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Summary

These investigations aimed to determine influence of the changes in relative humidity and temperature in storage facilities on the moisture in grain of stored soybean and maize. Soybean ("Podravka 95" variety) and maize ("OSSK 644" hybrid) were stored during 34 days at the temperatures of 0ºC and 20ºC, and relative humidity of 55%, 73%, 80% and 98%. At the temperature of 0ºC and relative humidity of 55% and 73%, moisture in soybean grain decreased, 2.4% and 1.9%, while at the relative humidity of 80% and 98% it increased, 0.2% and 0.6% after 34 days storage. At the temperature of 20°C and relative humidity of 55% and 73%, moisture in soybean grain decreased 4.0% and 0.7%, while at the relative humidity of 80% and 98% it increased 0.8% and 2.3%, as following. During 34 days storage at 0°C and relative humidity of 55%, moisture in maize grain decreased 0.2%, while at the relative humidity of 73%, 80% and 98% it increased 0.4%, 1% and 1.5%. At the temperature of 20°C and relative humidity of 55%, moisture in maize grain decreased 1.5% and at the relative humidity of 73%, 80% and 98% increased, 0.2%, 0.9% and 1.7%. Such investigations enable additional insights into the rate of changes in grain, and the influence on the grain viability in changed storage conditions.

Key words

soybean, maize, grain moisture, temperature, relative humidity, viability

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Introduction

Grain moisture content is among the most important factors that influence time needed for preservation of grain germination and longevity of grain viability, as well as the whole health status of the grain. However, as a hygroscopic material, grain establish equilibrium moisture with the surrounding area. High moisture level during the process of storing is unfavourable due to diminishing preservation ability of grain viability. Intensive respiration process enables activity of fungi and bacteria, producing favourable medium (temperature raise, moisture raise and heat release) for storage pests as insects and mites. Equilibrium of grain moisture content and relative humidity is essential for grain storing.

In various papers concerning grain storing and grain drying technology many authors deal with quantitative connections between storing factors and loss in grain viability. One of the first authors who tried to confirm this quantitative relation was Groves, 1917. He studied viability of wheat at the temperatures of 50 – 100 °C, and defined connection between viability and temperature by the equation:

$$T = a - b \log Z$$

where is T = temperature (°C), Z = time needed to destroy 75% of the grain, a and b = constants. The equation, as many others that followed, did not take into consideration influence of the grain moisture, and with no changes in constants values they were adequate only for a few moisture levels. Later, in many other papers influence of the grain moisture and temperature was included in equation. On the basis of the results obtained in studies on wheat and other cereals that were stored at 15 – 25°C and grain moisture content of 11 – 23%, scientists suggested equation that described interrelationship among temperature, grain moisture content and grain viability in the best way:

$$\log p50 = Kv - C1m - C2t$$

where is p50 = time needed for viability loss in 50% of grain, m = moisture content, t = temperature (°C), Kv, C1 and C2 = constants.

Harington, 1963 also applied this equation in his studies. His two principles were reinforced that lower moisture and temperature prevent grain deterioration. The first: each 1% decrease in grain moisture doubles the life of stored grain.. The second: each 5°C decrease in grain storage temperature doubles the life of the stored grain.. The first principle applies if moisture content is in the range of 14% to 5%. At moisture content higher than 14% development of microorganisms could quickly destroy grain germination ability, whilst moisture content lower than 5% causes reaction that accelerates deterioration of grain quality. Apart from these factors, grain germination depends on species, cultivar and even on the grain category.

It is known that temperature and relative humidity in the storage, as the most important variable factors, influence grain conditions which leads to the changes in grain quality. However, it is less known that values of the parameters that determine climate in the storage influence the grain of the plant species, and sometimes even cultivars. It is less known and difficult to find relevant results referring to the rate of changes in the grain in changeable storage conditions. Information on this is particularly important when determining regime of grain storing and regime of work in storages.

Such investigations on species and cultivars that are prevalent in our region will, therefore, ensure data about the rate of changes, and help in sharing information with those who daily make decisions about changing parameters of the environment in which the grain is stored.

Materials and methods

Grain of two plant species, soybean ("Podravka" cultivar) and maize (OSSK 44 hybrid) were used in the bioassay. 8 kg of each species were divided into 32 bags, four samples for measuring relative humidity and four for measuring temperature. Grain samples were previously cleaned from mechanical and organic debris, and checked for moisture level and temperature. Each sample weighing 250 g was placed into a linen bag and sealed.

Four samples of the single cultivar were placed into a tightly sealed plastic container. Containers were maintained at the four regimes of relative humidity, 55%, 73%, 80% and 98%, and at two regimes of temperature, 0°C and 20°C. So, each bioassay variant included two cultures in four replications. Favourable values of relative humidity were gained by applying saturated solution of NaCl (73%) and urea (80%), and with desaturated solution of NaCl (98%), and silica gel (55%). According to the article "Saturated solutions for the control of humidity in biological research" (Winston and Bates, 1960), saturated solution of urea kept above its surface relative humidity of 80% at the temperatures of 0°C and 20°C, which we proved correct. Saturated solution of NaCl at the temperatures of 0°C and 20°C should keep above its surface relative humidity 75% - 76%. However, in our case, it was different since the solution kept relative humidity of 73%. Desaturated solution of NaCl above its surface kept relative humidity of 98%, and silica gel of 55%. Bioassay was set at the Department for grain production and nurseries from 26 December 2005 to 29 January 2006. Every seven days during this period, changes in moisture absorption and moisture release in the grain were checked by the hygrometer Dickey John GAC2100. Data were subjected to analysis of variance.

Results

Soybean

Analysis of variance did not show significant differences in moisture content changes in soybean grain concerning different values of relative humidity (55%, 73%, 80% and 98%) and at the air temperature of 0°C and 20°C during 34 days storing period (Table 1).

Results of the grain moisture in soybean at 0°C

At the temperature of 0°C and relative humidity of 55% and 73%, moisture in soybean grain decreased, 2.4% and 1.9%, while at the relative humidity of 80% and 98% it increased, 0.2% and 0.6% after 34 days storage. (Figure 1).

Results of the grain moisture in soybean at 20°C

At the temperature of 20°C and relative humidity of 55% and 73% moisture in soybean grain decreased, 4.0% and 0.7%, while at the relative humidity of 80% and 98% it increased, 0.8% and 2.3%. (Figure 2).

Maize

Analysis of variance did not show significant differences in moisture content changes in maize grain concerning different values of relative humidity (55%, 73%, 80% and 98%) and at the temperatures of 0°C and 20°C during 34 days storing period (Table 2).

Results of the grain moisture in maize at 0°C

During 34 days storage at 0°C and relative humidity of 55%, moisture in maize grain decreased 0.2%, while at the relative humidity of 73%, 80% and 98% it increased, 0.4%, 1% and 1.5%. (Figure 3).

Results of the grain moisture in maize at 20°C

At the temperature of 20°C and relative humidity of 55%, moisture in maize grain decreased 1.5% and at the relative humidity of 73%, 80% and 98% increased, 0.2%, 0.9% and 1.7%. (Figure 4).

Table 1. Grain moisture in soybean at storage temperature of 0°C and 20°C

r.h.%	Treatments (examination date)					
	26 Jan. 2005	31 Dec. 2005	07 Jan. 2006	13 Jan. 2006	21 Jan. 2006	29 Jan. 2006
Grain m.c. (%) at storage temperature of 0°C						
55%	12.48	12.45	11.45	10.85	10.27	10.10
73%	12.60	12.23	12.18	11.88	11.70	10.68
80%	11.95	12.07	12.00	12.13	12.30	12.20
98%	12.32	12.45	12.30	12.48	12.65	12.90
Average	12.34	12.30	11.98	11.83	11.73	11.47
F test: 0.769^{ns}; Lsd test: Lsd 0.05=1.140, Lsd 0.01=1.5619						
Grain m.c. (%) at storage temperature of 20°C						
55%	12.38	11.93	10.45	9.40	8.75	8.32
73%	12.38	12.15	11.85	11.65	11.73	11.70
80%	12.50	12.27	12.38	12.80	13.15	13.30
98%	11.98	11.70	12.40	12.77	13.70	14.25
Average	12.31	12.01	11.77	11.66	11.83	11.89
F test: 0.175^{ns}; Lsd test: Lsd 0.05=2.363, Lsd 0.01=3.237						

Table 2. Moisture content (%) in maize at storage temperature of 0°C and 20°C

r. h. %	Treatments (examination date)					
	26 Jan. 2005	31 Dec. 2005	07 Jan. 2006	13 Jan. 2006	21 Jan. 2006	29 Jan. 2006
Grain m.c. (%) at storage temperature of 0°C						
55%	14.00	14.02	13.95	13.88	13.77	13.80
73%	14.48	14.63	14.70	15.02	14.80	14.93
80%	14.50	14.88	15.13	15.18	15.40	15.55
98%	14.07	14.32	14.75	14.98	15.18	15.63
Average	14.26	14.46	14.63	14.76	14.79	14.98
F test: 0.763^{ns}; Lsd test: Lsd 0.05=0.864, Lsd0.01=1.184						
Grain m.c. (%) at storage temperature of 20°C						
55%	14.30	13.57	13.18	13.10	12.88	12.75
73%	14.13	13.63	13.85	14.18	14.27	14.38
80%	14.10	13.75	14.38	14.68	14.88	15.05
98%	14.13	13.73	14.52	14.85	15.43	15.90
Average	14.16	13.67	13.98	14.20	14.36	14.52
F test: 0.534^{ns}; Lsd test: Lsd 0.05=1.211, Lsd 0.01=1.659						

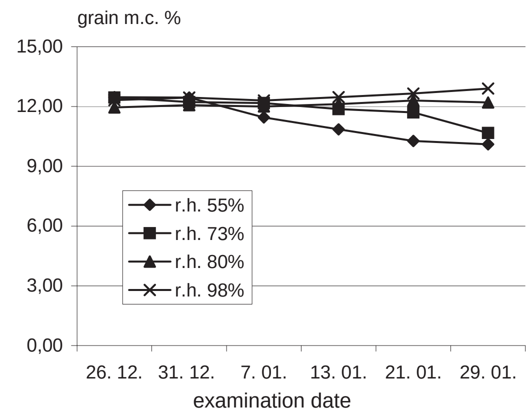

Figure 1. Soybean – grain moisture content (%) at 0°C

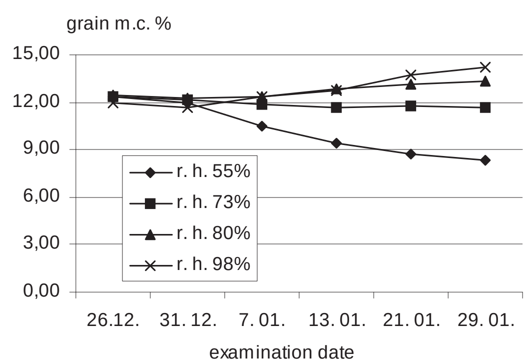

Figure 2. Soybean– grain moisture content (%) at 20°C

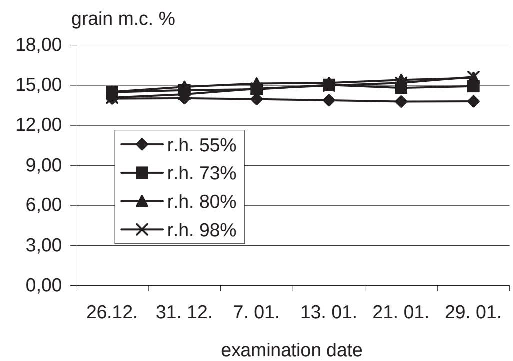

Figure 3. Maize – grain moisture content (%) at 0°C

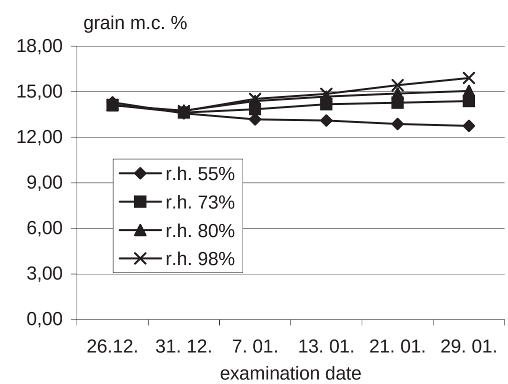

Figure 4. Maize – grain moisture content (%) at 20°C

Discussion

The main factors that influence viability of stored grain are temperature, relative humidity and oxygen content in grain pore space. Many empirical studies have been carried out referring to the influence of temperature and relative humidity to the grain viability, and in the most cases lower temperature and lower relative humidity proved to prolong it. Fewer studies dealt with the influence of the oxygen on the grain viability. However, it could be said that at the most species, the higher is oxygen content, the shorter is grain viability. Apart from that many studies reported exceptions to the rules. Some species such as citrus fruits (Barton, 1943), palms (Rees, 1963), and coffee (Huxley, 1964 and Bacchi, 1955, 1956), require high relative humidity to prolong grain viability.

In the case of cocoa, not only that high relative humidity has better influence to grain viability, but, the temperature of 10°C is found less favourable for grain than the temperature of 30°C. However, response of grain viability of the species to the given storage conditions is incomplete. In some cases there is possibility to confuse lower relative humidity with unfavourable effect of the rapid grain drying. Therefore, further research of the grain preserving for different species requires thorough additional investigations.

In contrast, our investigations proved the principle that longer grain viability required lower values of temperature, relative humidity and oxygen in grain pore space.

Conclusion

These investigations proved that moisture content in soybean ("Podravka" cultivar) and maize (OSSK 644 hybrid) grain changed depending on temperature (0°C and 20 °C) and relative humidity (55%, 73%, 80% and 98%) in storage facilities during the first 34 days of storing. However, the changes observed did not show significant differences and did not directly influence viability of soybean and maize grain.

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