SIMULATION OF CHANGES IN A WHEAT STORAGE BIN REGARDING TEMPERATURE

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Abstract

Storage of grains is a real chalange.There are issues about impact factors related to environmental factors like pedo - climatic conditions, agrothechnical conditions, harvesting and conditioning, genetic heterogenity, etc.
Also storage infrastructure is related to the efficiency of safe storage, properties of bulk of grains and the losses. Because most of the storage infrastructure is based on bins, concrete, metalic or bricks the study will be focused on this kind of storage behavior and the posibility of simulation of the process in laboratory conditions
There are differences in each country, region, even for storage facilities located in same area. The sun light is heating the storage, winds are colling down, air humidity can lead to the condensatios.
The aim of the study is to find a simple, proper and affordable solutions for farmens that have small metallic bins and are not very trained in the field of wheat grains storage, but also for storage facilities that have high numbers of small tonage bins with different kind of grains.

Key words: wheat, grains, storage, bins, laboratory simulation

INTRODUCTION

When the wheat grains are reaching the harvesting stage their condition is various. From the heterogenity, technological, pests and chemical - pysically points of view.

After harvesting, grains are not recomanded for direct use. There are issues about quality and yeld of milling. Those issues occurs because wheat grains physiology, harvesting conditions and equipments, handling and transport equipments, conditioning infrastructure and also because some degradations determined by pests and lack of temporary storage conditions (Kenneth J., P.E. Hellevang, 1998, Latif N., Lissik E., 1986).

In this way after wheat grains are reaching storage facility is necessary to provide proper conditions for safe storage for medium and long therm (Abramson, D., W. E. Muir, D. S. Jayas, 1999).

One of the important issue in order to maintain grain quality during storage of grains generaly and wheat grains in particular is related to the protection against pests by various techniques based mostly on reduction of humidity and temperature of grains by airflows and thickness of the grins layers. (Sun and Woods, 1997a, b). But the monitoring of the pests allow by mentioned correction actions the effective protections or even urgent use (Dunkel F.V., 1992).

In this view the dinamic of technological parameters of wheat grains during storage become the most important issue (Asseng S, 2002).

The drying of wheat grains is a preliminary and very important action that is enhancing and preparing the above mentioned aproach.

In this way there are various drying equipments and techniques. Combining them is the key of the succesfull drying. First step is the harvesting if is possible in dry days and after the sun is rising. There is also an intermediate factor that is critical, efficiency of harvesting, especialy from the heterogenity point of view. It is well known that the weeds parts and even main crop plants other than grains have high water percentage (Abramson, D., W. E. Muir, D. S. Jayas, 1999). The use of passive infrastructures for water percentage reduction can be use and increase the efficiency of the process and reducing the carbonfootprint of the wholle process, very important aproach in the view of the climating changes (global warming). The following stage is conditioning, that is reducing foreing parts, reducing of water content and sorting the wheat grains (Matz S., 1970).

Unfortunatelly those are extensive, time and energy consuming actions and are leading to wheat grains quality degradation. This actions are also rising wheat grains temperature and because the lower heat transfered capacity due to intergrains spaces the wheat grains are hard to be colling down, because the process is conducted during summer time (Jayas D.S., 1994).

The option of lowering the temperature is not suitable because huge costs related with huge amounts that are stored yearly - milions of tones.

At the end there is the storage themselve, process that is influenced by all factors mentioned before and their unpredictible evolutions.

The various wheat cultivars and their properties, various equipments for harvesting, handling, transportation and storage are hard to be considered and quantified, in this way is necessary to have proper tools for predicting grains quality evolution during storage (Bailey J. E., 1974, Bason M.L., 1993).

Valuable researches find theoretical solutions computer simulated for predicting the storage of wheat grains in bins, especialy how the quality parameters are changing (Canchun Jia, 2001). The issue about the theoretical, computer simulation aproach is related with the ability of farmers, storage operators, operators of the bins for feeding the livestock, etc to understand and use this models.

In this way we propose an indoor technical solution based on a air conditioned small room were plastic drums (bins) with caps are used for simulating the conditions from outdoor. The temperature and humidity of the environment from indoor space are regulated by sensor placed near outdoor metalic bins used for storage. Every time when the outdoor conditions are changing the indoor conditions are changing too. Because the bulk of wheat grains from metallic bins is very stabile from the changing of internal temperature and humidity the size of plastic drums can be small - 200 liters, because also in the 500 tone metallic bins there are affected by climatic changes just the external layers of wheat grains.

MATERIALS AND METHODS

The study was focused on following aspects:

- storage of wheat grains in metallic bins with known thermal transfer coefficient of the walls and roof,
- simulating in the laboratory of the storage in similar conditions by using small plastic bins,
- assessing wheat grains quality by accepted methods (A.A.C.C., 2000).

The location of the experience was Bicaci mill from Bihor county and University of Oradea, Faculty of Environmental Protection laboratory.

The experimental design of the study was the following:

Experience 1. Assessing the wheat grains from metallic bins.

The wheat grains stored in bulk in 500 t metallic bins were procured from private farmers, harvested in 2009 in late June.

There were taken in to study three cultivars that are wide spread in cropping in Bihor county, Dropia (D), Alex (A) and Crisana (C).

Because the company was contracted the production from autumn 2008 the cropping technology was similar for each batch (fertilization in March, April and May, there were used same fungicides, insecticides and herbicides, and this was eliminating this as variable.

The harvesting was done by the same contractor that also reduce the variability of the experience.

At the reception of the batches the conditioning was the same. The drying was done in the gas dryer up to 13 %.

The experience was considered fractioned experience.

After we recorded significant temperature and air humidity changes we reset the Experience 2 and start it from the beginning using wheat grains samples taken from metallic bins at the moment when the average temperature was changed. In this way we try to verify if the laboratory conditions in small plastic bins can be used to simulate and predict the storage in industrial metallic bins.

There were conducted analysis for following parameters:

1. Temperature of the external and internal environment and temperature of the external wheat grains layers from metallic bins,

2. Air humidity of the environment and internal microclimate from metallic bins,

3. Wheat grains water content from metallic bins,

4. Wheat grains protein content from metallic bins,

5. Wheat grains gluten content from metallic bins,

6. Wheat grains Zeleny index from metallic bins,

7. Flour power from metallic bins.

Experience 2. Assessing the wheat grains from plastic bins indoor conditions.

There were taken small batches 150 kg from each studied cultivar after drying and samples were stored in 200 l plastic bins indoor conditions.

The temperature was maintained at the values measured in Experience 1 by a thermostat and the air humidity was kept at the values also measured in Experience 1 by an air humidification unit.

Each time when there were temperature and air humidity changes in the Experience 1 we reset the Experience 2 and the wheat grains parameters were compared with Experience 1.

There were conducted analysis for following parameters:

1. Temperature of the external and internal environment and temperature of the external wheat grains layers from metallic bins,

2. Air humidity of the environment and internal microclimate from metallic bins,

3. Wheat grains water content from plastic bins,

4. Wheat grains protein content from plastic bins,

5. Wheat grains gluten content from plastic bins,

6. Wheat grains Zeleny index from plastic bins,

7. Flour power from plastic bins.

The methods used were according with the Agriceck NIR from Bruins Instruments provider. Excepting the Flour power that was done by Brabander Farinograph.

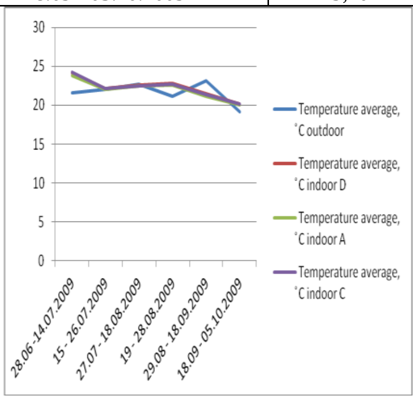
The calibration of was done by samples analyzed by classical methods (drying in owen at 105℃ for 5 hours, Kejdahl method, Wet gluten method, Zeleny method)

RESULTS AND DISCUSSION

After drying during storage there were recorded following temperature and air humidity values in Experience 1.

Table 1. Temperature and air humidity values in environmental and bins

Month	Temperature average, ℃				Air humidity average, %			
	outdoor	indoor			outdoor	indoor		
Cultivar		D	A	C		D	A	C
28.06 -14.07.2009	21,64	24,11	23,81	24,23	72	74	72	71
15 - 26.07.2009	22,04	22,18	22,08	22,16	69	72	71	71
27.07 - 18.08.2009	22,74	22,60	22,45	22,51	68	72	72	72
19 - 28.08.2009	21,16	22,80	22,62	22,66	75	72	72	72
29.08 - 18.09.2009	23,11	21,50	21,18	21,32	70	73	73	73
18.09 - 05.10.2009	19,10	20,20	20,06	20,14	72	74	74	74



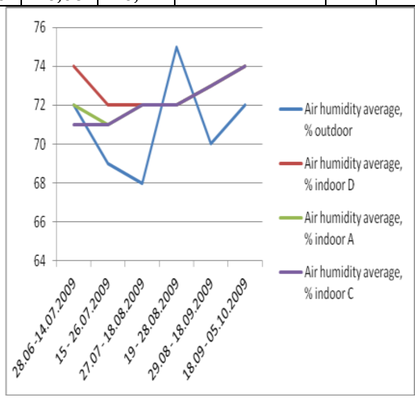


Figure 1. Temperature and air humidity evolution during storage

According with the data above there were conducted six time the Experience 1 and also four time Experience 2.

We considered that each time we started with "new" batches and we compared results at the next repetition of the Experience 1 and 2.

The values of the wheat grains parameters in each repetition of the experiences are presented in Table 2, 3, 4, 5 and 6.

Table 2. Wheat grains parameters first repetition 28.06 -14.07.2009

Parameter	Loading						Unloading					
	Metallic bins			Plastic small bins			Metallic bins			Plastic small bins		
Cultivar	D	A	C	D	A	C	D	A	C	D	A	C
Water content, %	13, 00	13,00	13,00	13,00	13,00	13,00	12,90	12,92	12,88	12,91	12,92	12,90
Protein content, %	14, 40	14,10	14,60	14,40	14,10	14,60	14,40	14,00	14,59	14,38	14,05	14,57
Gluten content, %	32	31	30	32	31	30	32	31	30	32	31	30
Zeleny index, %	55	54	57	55	54	57	55	54	57	55	54	57
Flour power	59	60	61	59	60	61	59	61	61	60	60	61

Table 3. Wheat grains parameters second repetition 15 - 26.07.2009

Parameter	Loading						Unloading					
	Metallic bins			Plastic small bins			Metallic bins			Plastic small bins		
Cultivar	D	A	C	D	A	C	D	A	C	D	A	C
Water content, %	12,90	12,92	12,88	12,90	12,92	12,88	12,85	12,90	12,85	12,87	12,90	12,86
Protein content, %	14,40	14,00	14,59	14,40	14,00	14,59	14,38	13,92	14,51	14,38	13,90	14,50
Gluten content, %	32	31	30	32	31	30	31	31	30	31	30	30
Zeleny index, %	55	54	57	55	54	57	55	54	56	54	54	56
Flour power	59	61	61	59	61	61	59	60	60	58	60	60

Table 4. Wheat grains parameters third repetition 27.07 - 18.08.2009

Parameter	Loading						Unloading					
	Metallic bins			Plastic small bins			Metallic bins			Plastic small bins		
Cultivar	D	A	C	D	A	C	D	A	C	D	A	C
Water content, %	12,85	12,90	12,85	12,85	12,90	12,85	12,83	12,87	12,81	12,85	12,87	12,83
Protein content, %	14,38	13,92	14,51	14,38	13,92	14,51	14,37	13,90	14,50	14,37	13,91	14,51
Gluten content, %	31	31	30	31	31	30	31	31	30	31	30	30
Zeleny index, %	55	54	56	55	54	56	55	54	56	54	54	56
Flour power	59	60	60	59	60	60	59	60	60	59	60	60

Table 5. Wheat grains parameters forth repetition 19 - 28.08.2009

Parameter	Loading						Unloading					
	Metallic bins			Plastic small bins			Metallic bins			Plastic small bins		
Cultivar	D	A	C	D	A	C	D	A	C	D	A	C
Water content, %	12,83	12,87	12,81	12,83	12,87	12,81	12,88	12,88	12,85	12,87	12,89	12,86
Protein content, %	14,37	13,90	14,50	14,37	13,90	14,50	14,38	13,91	14,51	14,38	13,90	14,51
Gluten content, %	31	31	30	31	31	30	31	31	30	31	31	30
Zeleny index, %	55	54	56	55	54	56	55	55	57	55	56	56
Flour power	59	60	60	59	60	60	60	61	61	60	61	60

Table 5. Wheat grains parameters fifth repetition 29.08 - 18.09.2009

Parameter	Loading						Unloading					
	Metallic bins			Plastic small bins			Metallic bins			Plastic small bins		
Cultivar	D	A	C	D	A	C	D	A	C	D	A	C
Water content, %	12,88	12,88	12,85	12,88	12,88	12,85	12,86	12,85	12,84	12,83	12,84	12,84
Protein content, %	14,38	13,91	14,51	14,38	13,91	14,51	14,37	13,88	14,49	14,35	13,88	14,48
Gluten content, %	31	31	30	31	31	30	32	32	31	31	31	30
Zeleny index, %	55	55	57	55	55	57	56	56	57	56	56	57
Flour power	60	61	61	60	61	61	61	61	62	61	61	62

Table 6. Wheat grains parameters sixth repetition 18.09 - 05.10.2009

Parameter	Loading						Unloading					
	Metallic bins			Plastic small bins			Metallic bins			Plastic small bins		
Cultivar	D	A	C	D	A	C	D	A	C	D	A	C
Water content, %	12,86	12,85	12,84	12,86	12,85	12,84	12,86	12,86	12,84	12,84	12,85	12,87
Protein content, %	14,37	13,88	14,49	14,37	13,88	14,49	14,36	13,87	14,48	14,36	13,86	14,47
Gluten content, %	32	32	31	32	32	31	32	31	31	32	32	31
Zeleny index, %	56	56	57	56	56	57	57	56	58	57	56	57
Flour power	61	61	62	61	61	62	61	62	63	61	62	64

According with the results we recording correlations between Experience 1 and Experience 2.

The researches were shown that physically parameters were variable according with the environmental conditions. There was similar evolution in all samples from indoor experience and this was very close to the outdoor experience.

The chemical parameters were also homogenous in evolution and between Experience 1 and Experience 2 there were similar values and same slope.

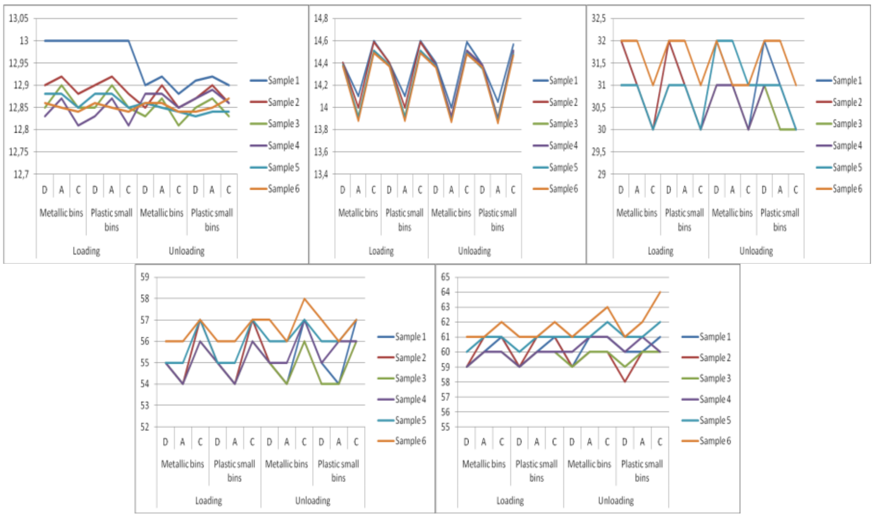


Figure 2. Comparison betwen saples during storage from the water content, protein content, gluten content, Zeleny index and flour power point of view

However the results were concluding regarding the direct related environmental conditions parameter - grain humidity in Experience 1 and in simulated Experience 2.

Also there was recorded a small decreasing of protein content but in correlation with gluten content and Zeleny index this was not significant and was predictable if we follow the Experience 2 results.

Flour power was increasing most significant during storage with small variations due to climatic environment and is related with maturation of the wheat grains during storage after harvesting.

CONCLUSIONS

The conclusion of this paper are related more with validation of a method than the results recorded.

In this way it was relevant that dynamic of key parameters for bakery wheat grains - Gluten content and Zeleny index - were similar in Experience 1 and Experience 2 which lead to the conclusion that the simulation in laboratory even in small batches can be use as prediction method for large scale storage infrastructure if there is a correlation with predicted environmental conditions that can be replicated in laboratory easily.

In subsidiary we can add that the method was verified on 3 different cultivars and at six temperature and air humidity levels with results that shown also stability of the bulk wheat grains stored in metallic bins.

The wheat grains from Crisana cultivar shown that the parameters are most stabile and are improving highest.

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