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THE EVOLUTION OF THE QUALITY PARAMETERS ON THE STORED WHEAT

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Abstract

As one of the main grains consumed throughout the world, wheat is very important for food security. Harvesting and storage periods may have negative effects on physical and physiological quality and increased fungal incidence in the silo, especially when certain essential conditions for carrying out these processes are not complied with. Quality of wheat is changing during storage and this can influence the quality of bread and bakery products. During storage, the moisture of wheat must be keep at a safety level to prevent germination process and also the insect infestation have to be under control. This work aimed to monitoring the changes in the quality parameters of the wheat stored for a period of at least two years. The analysis carried out on the basis of which the observations were made were the following: moisture content, protein content, hectometer mass, falling number, gluten content, and E-nose analysis. The results of the analysis have shown that in the stored cereals certain quality properties have been modified, but over time the deterioration occurs more and more aggressively.

Key words*: wheat, storage, physical- chemical analysis, quality parameters.*

INTRODUCTION

One of the most important grains grown around the globe is wheat. This cereal is a rich source of nutrition in carbohydrates and proteins. Wheat is collected in a short period of time, but then it is processed and used throughout the year. Therefore, wheat must be stored in adequate conditions to maintain the nutritional and rheological properties necessary for use in the milling and bakery industry (Tipples, 1995). Wheat is considered to be the essential crop, with an overall production of around 771 million tons in 2019. The world's largest wheat supplier is considered to be the European Union. Romania is in the top five largest wheat producers in the European Union, with a growing area of 2.106.813 hectares and an annual production of 10.144.000 tons. More than half of the annual wheat production in Romania is exported to different countries around the world (USDA, 2015). On the other hand, the Romanian population has a high consumption of wheat and wheat products (364.6 g/day), more than the European average (295.4 g/day) and twice the world average (178.8 g/day) (FAOSTAT, 2015). Wheat crop in Romania is a traditional and fundamental feature for national agriculture. The essential area where most wheat is grown is the Danube plain in the south of the country. Other important areas of wheat growth are Transylvania, the northern part of Moldova in the north-east of Romania and the Banat region in the south-west (Bălan, 2015). The wheat is grown only for a limited period during the year; therefore, it must be stored safely for consumption throughout the year. Infestation is a hard blow to food security, as it causes a huge amount of losses suffered from feeding insects inside the grain, as well as a deterioration in the quality of the stored wheat grains. The main cause of insect and pest attacks is due to poor storage conditions and lack of a quick method for quality analysis during storage. Insects are the most adaptable forms of life; once they proliferate over the grain, it begins to degrade in a logarithmic progression. Of these, two major insects which are the main cause of infestation in stored wheat are *Sitophilus oryzae* and *Rhizopertha dominica*. Both insects propagate eggs into wheat grain and start to grow by feeding on the starch until they appear as adult insects (Jarruwat et al., 2014). Wheat grains have a moisture content of between: (9-5%), dry matter (80-90%) and crude protein (7-17%). The economic value of wheat is determined on the basis of its protein content, as it indicates the final quality of the flour to the consumer class. The moisture content of the wheat grain is given by its relevance for long-term storage (NZFMA, 2014). The main agents of wheat quality characteristics are tested by analytical quantification of a range of parameters such as wet gluten content, protein concentration, sediment value and falling number. All these parameters have their own distinct role in anticipating the quality of wheat flour. The protein content plays an essential role in describing the characteristics of the flour, while the way gluten is formed and shown after hydration highlights the ability of the flour and its efficiency to retain the gas during fermentation and ensures the successful completion of the final product (Pareyt et al., 2015).

The purpose of this study was to observe the development of certain essential parameters expressing the quality of the wheat during two years of storage. The samples were analyzed during 2019 and were collected in the same year and analyzed again in 2020.

MATERIALS AND METHODS

Raw materials

Twelve samples of wheat (*Triticum aestivum* L.) have been taken for this work. The wheat from which the samples were taken was grown on the territory of Romania in the south-east part of the country. Its storage was in raffia sacks, in proper grain storage. Sampling has been carried out by a qualified person. The samples were packed in plastic bags weighing 2 kg each. During the analysis the samples were stored under optimal storage conditions. It is well known that the maximum storage temperature should be 15ºC to avoid the deterioration of wheat quality (Fletcher, 2010). In this study, low temperatures were taken into account to maintain quality during grain storage. All functional properties were measured at room temperature (23 ± 2ºC). Weighing of the samples was carried out with the analytical scales. This study was carried out in Bucharest, Romania.

Moisture content

The determination of the moisture content was carried out by rapid methods using two devices: Aquamatic AM 5200-A and Inframatic IM 9500 (Perten Instruments, Hudinge, Sweden). For the accuracy of the results, the equipment shall be checked and calibrated annually.

Protein content

The Inframatic IM 9500 equipment (Perten instruments, Hudinge, Sweden) was used for this method. Analysis has been conducted according to the working instructions for the equipment provided.

Hectolitre mass

The analysis for the determination of the hectomical mass was carried out using the Nilematic tools (Tripette & Renaud tools for results 128, France) and Aquamatic AM 5200-a (Perten instruments, Hudinge, Sweden). Sample testing for this determination was carried out on both equipments.

Gluten content

Wet gluten has been determined according to ISO method 21415-2: 2016 using Glutomatic 2200 equipment (Perten instruments, Hudinge, Sweden). The determination of gluten verifies the physical properties of the dough (Kashta, 2014). The gluten content gives nourishment to the bakery products. This is a very important protein due to vasco-elastic properties (Kaushik et al., 2015).

Falling Number

The determination of the drop index was carried out using Perten FN 1000 equipment and automatic stirrer for Shakematic viscometer 1095 (Perten instruments, Hudinge, Sweden), according to SR EN ISO 3093:2010. The grinding of the samples was carried out by means of laboratory mallets Perten LM 120. The grain size check was carried out with sieves with dimensions of holes of 0.2 mm, 0.5 mm and 0.710 mm, ISO3310-1:2016 Vibitarion filter. The mill-check groats was sieved using the Vibitarion filter vibratory base for 10 minutes. The samples obtained from grinding have been kept in optimum conditions of temperature and humidity.

E-nose analyze

The principle of the method is to generate head space in the capsule vial in which the sample is contained, to extract a quantity from it (µl, amount determined in the method) by means of syringe and to inject into the System Array Sensor (SAS). This gives the sensory print with the primary data, which is then analyzed statistically and the differentiation index is obtained. From the received samples, 2 g were weighed in 10 ml glass vials and subsequently sealed. 3 identical vials were prepared from each sample. The samples have been heated and agitated in the oven at 70°C for 500 seconds at a shaking speed of 500 rpm, the syringe being heated to 80°C. From the volatile part generated inside the vial, 2000 µl were injected into the 18-sensor system for recording the total volatile print and comparing them between the samples (Figure 1).

Figure 1. Common wheat samples harvested since 2019

Figure 2. A-Prometetheheus Multisensor System (E-nose)

Equipment and materials used: A-Prometheus multi-sensor system (Figure 2); 10 ml vials; caps; vial sealer; analytical balance; spatula/tweezers; calibration standards.

RESULTS AND DISCUSSIONS

Moisture content of the samples (Table 1)

Table 1. Moisture of wheat samples over two years of storage

Samples	Results obtained	
	2019	2020
S_1	13.4 %	13.1%
S_2	13.4%	12.8%
S_3	13.3%	13.0%
S_4	13.0%	13.2%
S_5	12.9%	13.1%
S_6	13.5%	13.7%
S_7	13.3%	13.8%
S_8	13.3%	13.4%
S_9	12.8%	13.1%
S_{10}	13.4%	12.4%
S_{11}	12.7%	13.4%
S_{12}	12.9%	13.5%

The results of the humidity analysis of the twelve samples are given in this table. As it can be seen, the wheat does not change its moisture in two years, and there are only small changes in moisture, which remain almost unchanged. It can be observed that the moisture content values are not exceeded, resulting in optimal preservation.

Variation in protein content over time (Table 2)

Table 2. Protein of wheat samples during two years of storage

Samples	Results obtained	
	2019	2020
S_1	12.9 %	13.4%
S_2	12.6%	12.7%
S_3	12.6%	12.6%
S_4	12.4%	12.8%
S_5	12.2%	13.0%
S_6	12.6%	12.6%
S_7	12.2%	12.7%
S_8	12.2%	12.0%
S_9	12.0%	12.9%
S_{10}	12.1%	12.4%
S_{11}	12.7%	12.0%
S_{12}	12.5%	12.2%

It can be observed that the results obtained for protein content are very close in value, so the protein content has not undergone any major changes as a result of storage conditions during those two years.

Evolution of the hectolitre mass (Table 3)

Table 3. The hectolitre mass of the two-year storage park

Samples	Results obtained	
	2019	2020
S_1	77.8 kg/l	79.4 kg/l
S_2	78.9 kg/l	77.0 kg/l
S_3	78.4 kg/l	77.8 kg/l
S_4	76.7kg/l	77.0kg/l
S_5	77.6 kg/l	77.1 kg/l
S_6	78.9 kg/l	78.3 kg/l
S_7	78.6 kg/l	77.8 kg/l
S_8	78.6 kg/l	77.8 kg/l
S_9	76.7 kg/l	77.0 kg/l
S_{10}	81.2 kg/l	79.8 kg/l
S_{11}	79.0 kg/l	79.6 kg/l
S_{12}	80.8 kg/l	79.8 kg/l

The difference between the two years in the case of a hectolitre mass is not significant, which means that storage has not affected wheat in this respect, although the values obtained are not favorable to a high quality wheat.

Wet gluten (Table 4)

Table 4. Wet gluten content

Samples	Results obtained	
	2019	2020
S_1	26.4 g	25.9 g
S_2	24.1 g	25.8 g
S_3	24.2 g	25.5 g
S_4	24.0 g	24.7 g
S_5	24.4 g	25.3 g
S_6	24.8 g	23.8 g
S_7	26.2 g	25.0 g
S_8	24.0 g	22.6 g
S_9	26.3 g	25.9 g
S_{10}	24.2 g	23.5 g
S_{11}	27.2 g	25.7 g
S_{12}	26.9 g	27.4 g

Data from wet gluten analysis were recorded in this table. Wet gluten did not vary widely between the years in which it was stored. No lower gluten content than 22.0 g was recorded, no high gluten value above 28.0 g was recorded, the highest value obtained was 27.2 in 2019 and the lowest value recorded for 22.6 in 2020. Comparing the two years the evolution of gluten was not dramatic to be able to say that the storage factors had a negative or positive impact on this property.

Falling Number (Table 5)

Table 5. Falling Number results

Samples	Results obtained	
	2019	2020
S_1	338 s	407 s
S_2	374 s	420 s
S_3	385 s	357 s
S_4	274 s	293 s
S_5	299 s	272 s
S_6	361 s	402 s
S_7	322 s	359 s
S_8	406 s	448 s
S_9	394 s	421 s
S_{10}	408 s	455 s
S_{11}	372 s	390 s
S_{12}	269 s	298 s

When comparing the two years there was no data with very large differences between the values obtained.

Data obtained indicate low amylolytic activity, only sample 4 and 12 fall into a normal value of amylase activity (220-280 s).

The results obtained indicate that the bread to be made from this flour will not develop enough, the kernel will be small and too dry.

Storage conditions have not significantly influenced the drop index, although it can be observed that in most samples it is increasing, resulting in very low and impy amylasic activity to flour that will have to be improved to achieve the desired result.

E-nose

Volatile compound analysis results (Figures 3-15):

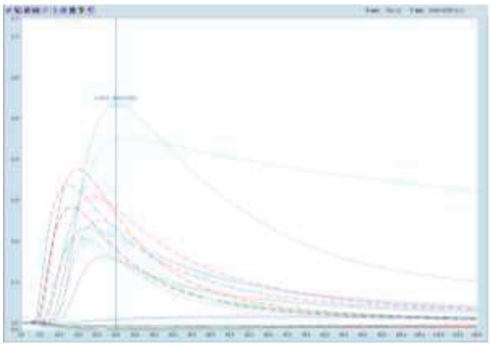

Figure 3. Sample 1 - common wheat

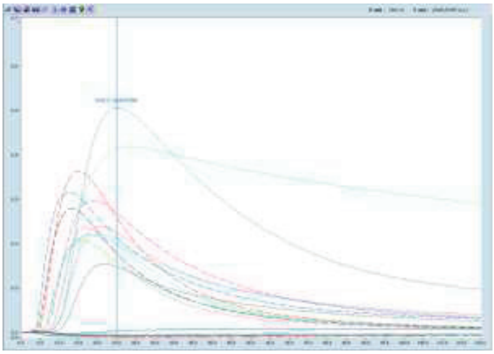
Figure 4. Sample 2 - common wheat

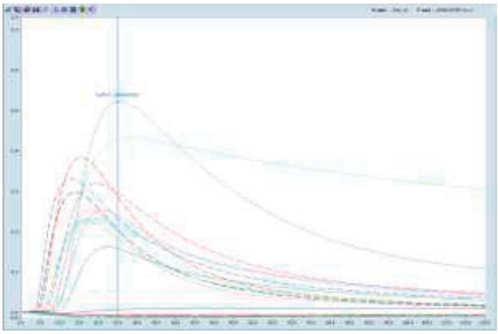
Figure 5. Sample 4 - common wheat

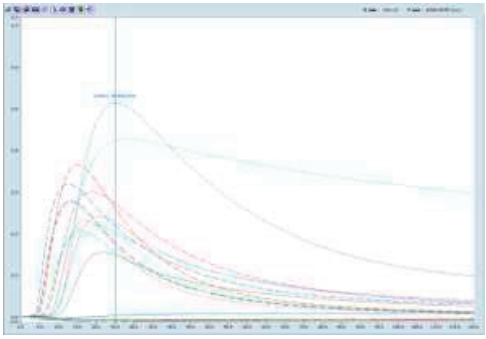
Figure 6. Sample 3 - common wheat

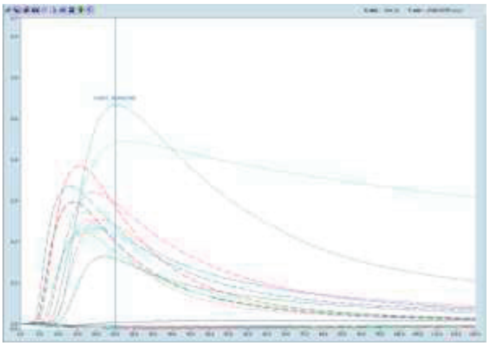
Figure 7. Sample 5 - common wheat

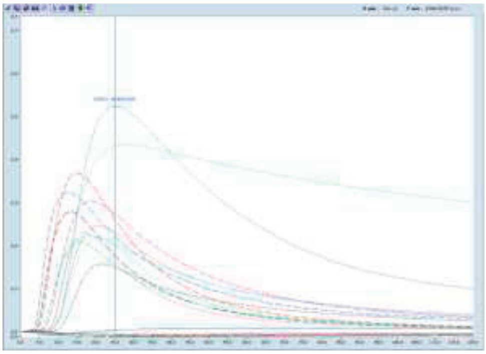
Figure 8. Sample 6 - common wheat

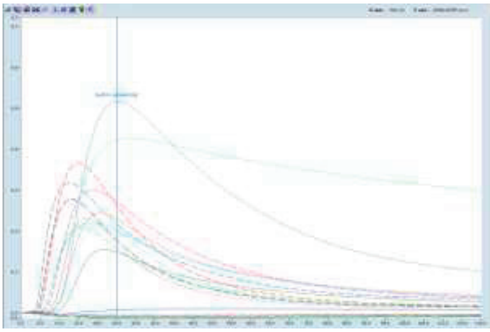
Figure 9. Sample 7 - common wheat

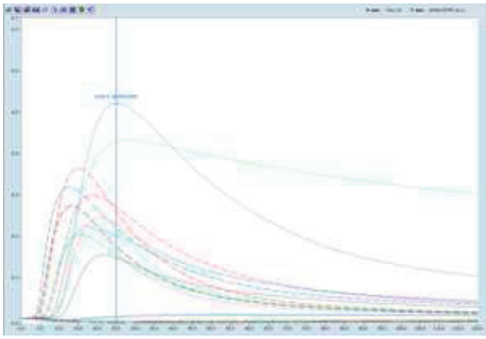
Figure 10. Sample 8 - common wheat

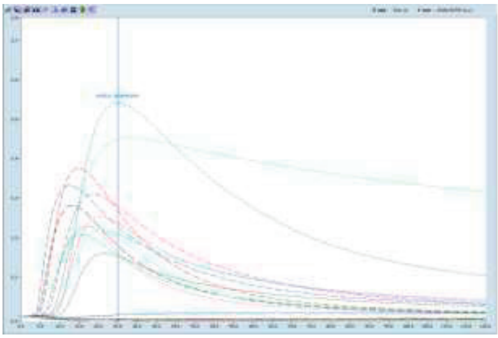
Figure 11. Sample 9 - common wheat

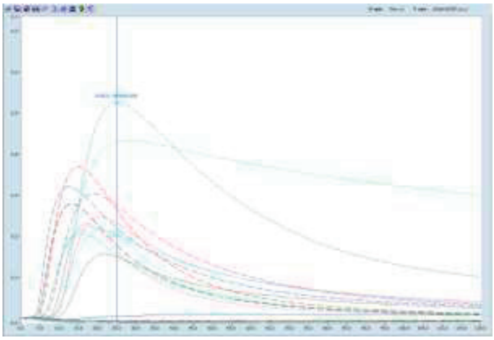

Figure 12. Sample 10 - common wheat

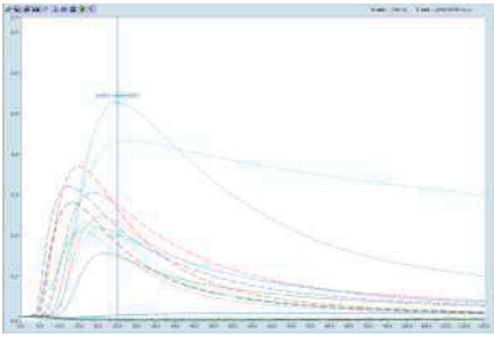

Figure 13. Sample 11 - common wheat

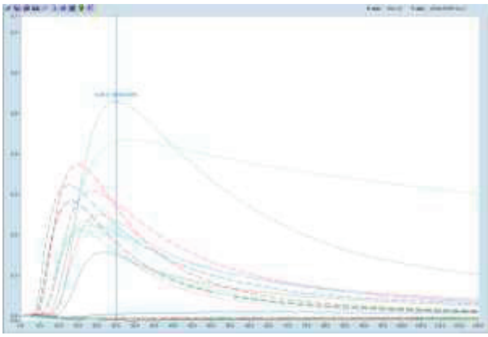

Figure 14. Sample 12 - common wheat

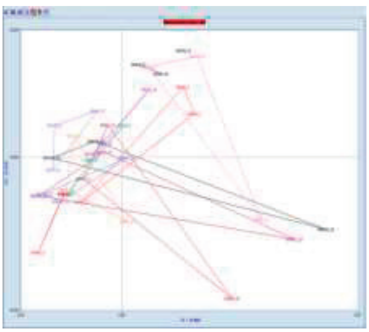

Figure 15. Differentiation of the 12 common wheat samples

In these charts the response of the 18 sensors of the α-Prometheus multisensor system for each sample is shown. Following the sensory analysis of volatile compounds in the twelve common wheat samples collected since 2019, the response given by the 18 sensors did not show any significant differences in the way that any contamination of certain samples could be concluded.

CONCLUSIONS

The results from this study show that moisture, protein, hectolitre mass, gluten content and falling number have not been significantly altered under the storage conditions under which the wheat was kept. In the two years the wheat was stored, the parameter values did not have any semi-operative variations. In the case of Falling number analysis where most of the results obtained show a low amylasic activity because the drop index values are higher than 280 s, certain factors such as temperature variations may lead to wheat germ, and this process leads to even lower alpha-amylasic activity. The samples were differentiated using PCA-type statistical analysis (analysis of main components). Following the interpretation of the data, a discrimination index was obtained using the PCA which provides an assessment of the quality of the discrimination on the selected plan. This assessment is given by the area between the groups and the size of a group, the maximum value for the differentiation index is 100 if the samples are different. The wheat samples analyzed had a negative differentiation index, which leads to the conclusion that the samples are very similar, no significant differences in volatile smell composition can be identified.

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