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COLOR SORTING OF BREAD-MAKING WHEAT AND CHANGE OF TOXIN CONTENT

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Abstract: We continued our experiment on the basis of results of preceding year in order to prove it is possible efficiently decrease DON-toxin content of bread-making wheat by color sorting. DON-toxin content is serious food-safety risk, that is why it is important to decrease this risk by application technical solution in the mill technology. Sortex Z+ color sorting machine proved to be able to select efficiently the grain of wheat infected by Fusarium species. According to the result the mycotoxin content of wheat decreased. The wheat is used to the production of basic foods, so we must pay special attention to the food safety aspects, and the wheat shouldn't contain contamination or it should be below allowable limits.
Keywords: toxin content, color sorting, Sortex Z+, mill technology

1. INTRODUCTION

The experiment was organized at Júlia Malom Ltd. and we investigated wheat lots harvested in 2013. The objective was to test opportunity of decreasing of DON-toxin content in the milling technology process. DON-toxin content is produced by Fusarium species. The fusarium contamination means economical and food safety risk in the primary production. (Puskás, 2013.) The flour made from contaminated grains of wheat can be a serious food safety risk.

Basic foods and primary products are made from bread making wheat and flours. These are the products which are consumed in great volumes by all segments of population – from children to adults. Consequently from the food safety aspect distinguished attention must be paid not to expose customers to this risk. (Ambrus, 2014) On the other hand DON-toxin is known to be a very stabile chemical material. Its concentration doesn't decrease in the course of storage and it doesn't disintegrate under the influence of heat. Therefore we have to make efforts to minimize toxin content of wheat before milling, but at the least to keep below allowable limits. Nowadays toxin content can be decreased after harvesting and storing also by application of modern milling industry equipments and technical conditions. In the course of cleaning process of grain of wheat not just the physical dirt can be removed, but quantity of mycotoxin can be decreased also avoiding by this the chemical danger. Toxin test of grain lots harvested in 2013 indicated the effects of color sorting of wheat-grains on decreasing of toxin content.

Figure 1. Sortex Z+ optical sorter

Toxin concentration can be different in the internal layers of the grain depending on the characteristic of the Fusarium infection. (Veres 2007.; Kótai et al, 2012) This is why we continued experiment with wheat samples harvested in 2014. The objective was to prove it is possible to decrease toxin level in the mill technology under different infection circumstances by operation of modern equipment like Sortex Z+ color sorter. (Figure 1)

2. MATERIAL AND METHOD OF EXPERIMENT

Similarly to previous investigations the samples were taken for the test at Júlia Malom Ltd. The samples were taken in the first phase of milling technology just before and after color sorting. The time of sampling was settled in accordance with performance of Sortex Z+ machine. This method ensured the test same samples before and after sorting.

We investigated DON-toxin content of 20 samples during the experiment. The samples taken before sorting by Sortex Z indicate the initial toxin content of investigated wheat (Figure 2). After sorting the mycotoxin decreasing efficiency of the process can be evaluated by means of analytical results of relevant samples.

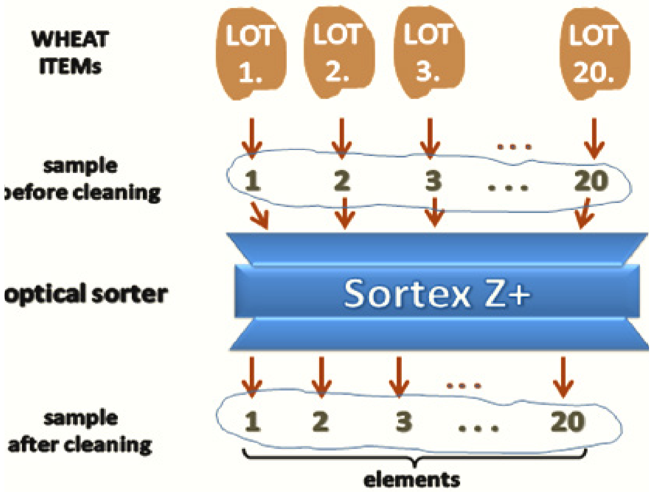

Figure 2. The method of sampling

Toxin analysis was carried out in own laboratory of Júlia Malom Ltd with AgraQuant Deoxinyvalenol test kit which is a quantitative enzyme-linked immunosorbent assay (ELISA) for the analysis of DON in cereals developed by Romer Labs (Figure 3).

Figure 3. The ELISA tester

Highest level of this toxin content in different products is strictly regulated in the European Union. Regulation 1881/2006/EC of the European Parliament and of Council determines the highest acceptable level of contamination. DON toxin limit in unprocessed bread wheat is 1,25 ppm, and in unprocessed durum wheat is 1,75 ppm. Allowable limits must be kept compulsorily.

The evaluation was made by hypothesis analysis. The elements of two samples came in pairs (before and after sorting element in a pair) from the same lot of wheat, and DON toxin content was tested in each element. Thus the lot and the elements of samples are not independent from each other from mathematical respect. We applied „one-sample T-test" to the statistical analysis, in which the difference of two values, that is difference (d_i-t) was ordered to the element.

We used „null-hypothesis" at 5 % significance level to answer whether the difference between DON values before and after color sorting under same condition is negligible.

From mathematical aspects we can investigate in four logical steps whether the hypothesis is correct or it should be rejected. Values of t-probe function were calculated with MS Excel software, thus we investigated the rightness of null-hypothesis in two steps. (The last three steps were drawn together.)

- First step: We analysed fulfillment of precondition to carrying out pared t-probe According to our assumption the distribution of population is normal. The results of measuring was completed with equipments in practice and employed chemical and physical rules. Thus they fulfilled the precondition of normality.

Mathematically we should verify normality with so-called χ^2-probe, but owing to number of datas (n=20<50) this wouldn't be exact. Presumably if we would make quite a number measurement, we would experience that DON values and their differences have normal distribution.

Table 1. Analysis of difference-sample to prove normality

No.	DON values before cleaning (x_i)	DON values after cleaning (y_i)	Difference ($d_i = x_i - y_i$)	Deviation from mean ($d_i - \bar{d}$)
1.	0,34	0,23	0,11	-0,041
2.	0,35	0,22	0,13	-0,061
3.	0,36	0,26	0,10	-0,031
4.	0,36	0,27	0,09	0,160
5.	0,41	0,40	0,01	0,060
6.	0,42	0,40	0,02	0,050
7.	0,43	0,40	0,03	0,040
8.	0,43	0,41	0,02	0,050
9.	0,47	0,43	0,04	0,030
10.	0,48	0,45	0,03	0,040
11.	0,54	0,45	0,09	-0,021
12.	0,60	0,50	0,10	-0,031
13.	0,62	0,52	0,10	-0,031
14.	0,62	0,53	0,09	-0,021
15.	0,65	0,60	0,05	0,019
16.	0,66	0,62	0,04	0,030
17.	0,78	0,69	0,09	-0,021
18.	0,83	0,71	0,12	-0,051
19.	1,30	1,22	0,08	-0,011
20.	1,36	1,31	0,05	0,019

Our hypothesis concerning to normality is reinforced by datas of Table 1. In the column „deviation from mean" the signs of the datas shows that half of them are below the mean (10 values are negative), and half of them above the mean (10 values are positive).

- Second (drawn together) step: We defined the value of „t-probe function" with Excel program. The mathematical basis of calculation can be described by the following equations.:

$$t = \frac{\bar{d}}{s_{\bar{d}}},$$

where: $\bar{d} = \frac{\sum_{i=1}^{n} d_i}{n}$ and $s_{\bar{d}} = \sqrt{\frac{\sum_{i=1}^{n}(d_i-\bar{d})^2}{n(n-1)}}$

Thereafter we compared the values of t-probe belonging to the relevant degree of freedom (which can be seen in the Excel table) with t values of probe function. That was the basis for acception or rejection the null-hypothesis.

3. RESULT AND EVALUATION

Data of initial DON-toxin content of wheat can be seen in the Figure 4., where the elements of sample arranged by size. The figure indicates well that in the case of tested elements Sortex Z color sorting decreased DON-toxin content of wheat. But there is big difference between degree of decrease if we examine the individual elements.

The hypothesis analysis is necessary because the effectiveness of sorting must be proved undoubtedly. We have to clearly express, the decrease is not owing to chance.

Drawn up the starting point: there are tandem samples with „n" elements and it is supposed those come from population with normal distribution. The arithmetic mean and standard deviation isn't known. Toxin data of samples before cleaning is indicated by „x", and data of cleaned wheat samples by „y". Namely:

» Elements of wheat samples before cleaning (X): x_i

» Elements of cleaned wheat samples (Y): y_i

where i= 1,…,n

As it was above-mentioned according to arrangement of research samples data that belonging together were analysed by paired t-probe. The average of data before cleaning indicated μ_1, and standard deviation σ_1. Accordingly with this logic the average of cleaned wheat samples is μ_2, and standard deviation is σ_1.

Hypotheses are the followings:

» H0 = null-hypothesis when there is no significant difference between theoretical mean of two samples. That is:

$$\mu_1 = \mu_2$$

» H1= according to alternative hypothesis theoretical average of samples before mean is significantly higher than the average of sample after cleaning:

$$\mu_1 > \mu_2$$

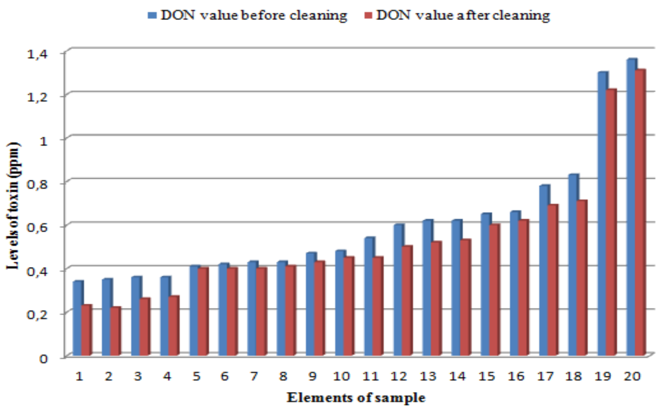

Figure 4. DON-toxin content of wheat before and after cleaning

Table 2. Two sample paired t-probe for probable value

	DON value before cleaning	DON value after cleaning
Expected value	0,6005	0,532
Variance	0,0824366	0,084154
Observations	20	20
df	19	
t value	8,2097227	
P(T<=t) unpaired	5,694E-08	
t critical unpaired	1,7291328	
P(T<=t) paired	1,139E-07	
t critical paired	2,093024	

In our case the unilateral alternative hypothesis has sense. Figure 4 clearly presents the color sorting have an influence on decreasing of DON-toxin content of wheat.

The Table 2 demonstrates the critical value of Student's t-distribution at 5% significance level less than calculated value. That is null-hypothesis should be rejected, because theoretical means of two samples present significant difference. That is:

$$\mu_1 \neq \mu_2.$$

So it can be stated the selection by color proved to be effective in certain circumstances, at 95% probability level. Results were not induced by chance.

In the matter of food safety questions it is worth to examine null-hypothesis at lower significant level also. Data of the table displays, that

$$\alpha=0{,}0005,\ t=3{,}883$$

That is the effect of treatment is justifiable at higher probability level also, and the null-hypothesis can be rejected.

4. CONCLUSIONS AND SUGGESTIONS

Similarly to examination of wheat samples harvested in 2013, we proved the efficiency of color sorting on decreasing of toxin content of wheat in samples cultivated in 2014. It was important because the efficiency of a Sortex Z+ color sorting machine was justifiable in two very different years with different weather and infection circumstances.

It can be summarized, that application of adequate technical equipment contributes to fulfil food safety requirements on a higher level in the course of food processing. According to the results of the experiment the application of Sortex Z+ color sorting can be suggested in the milling industry.

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