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THE ROLE OF COLOR SORTING MACHINE IN REDUCING FOOD SAFETY RISKS

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ABSTRACT

It is the very difficult problem how we can decrease food safety risks in the product, which was polluted in process of cropping. According to professional literature almost the prevention is considered as an exclusive method to keep below safe level the content of DON toxin. The source of food safety in food chain is that the primary products suit the food safety requirements. It is a very difficult or sometimes it is not possible to correct food safety risk factors - which got into the products during cultivation - in the course of processing. Such factor is fusariotoxin in fodder and bread wheat. DON toxin is the most frequent toxin in cereals. The objective of the searching was to investigate, if it is possible to decrease DON toxin content of durum wheat and to minimize the food safety risk by application milling technology with good production practice and technological conditions. The samples were taken in the first phase of milling technology just before and after color sorting. According to measuring results Sortex Z+ optical sorting decreased DON toxin content of wheat. This mean that the food safety risks can be reduced by Sortex Z+ optical sorting machine. Our experiments proved if there is color sorting in the cleaning process preceding the milling of wheat then a part of the grain of wheat infected by Fusarium sp. can be selected. This improves the food safety parameters of given lot of wheat and decrease the toxin content. The flour made from contaminated grains of wheat can be a serious food safety risk. We would like to support scientifically the technical development of milling technology with our experimental data.

Keywords: food safety; DON toxin; fusarium; wheat; *Triticum durum*

INTRODUCTION

During the course of wheat process, we have to make efforts to minimize toxin content of wheat before milling, but at the least to keep below allowable limits.

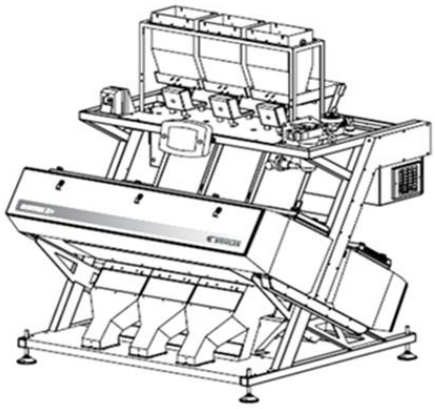

Figure 1 Sketch of Sortex Z+ optical sorter.
(Source: Sortex Z operator's manual).

Basic requirement is that these products don't contain microbiological, chemical and other contaminations, or at least not more than the maximum allowable limits **(Commission regulation (EC) No 1881, 2006)**. Products made of cereals, such as flour, bread and bakery products are classifiable as basic foods, but we consume lot of pasta and cake also. Large-scale consumption of basic foods is a feature of adult and children population equally. At these products, the fundamental importance to use primary materials which are free from biological and chemical pollutants is unambiguous.

The mycotoxins in food are secondary metabolic products of moulds, which have strong toxic effect. These can cause heavy complications in human and animal organizations, can result illness shorter or longer time, and can cause lasting damage. The species belong to Fusarium family produce significant quantity of toxin, which contain several fuzariotoxin. The Fusarium species are parasites on several cultivated plants. In most cases they infect the cereals. So they might cause significant damage both in plant cultivation and animal husbandry as well as there might be considerable human-health consequences. **(Mesterházy, 2015; Summerell at al., 2010; Stanic at al., 2015; Leslie and Logrieco, 2014; Remža at al., 2011; Adam at al., 2002)**. Deoxinivalenol, otherwise vomitoxin became known as DON toxin, is frequent representative of fusariotoxins. This toxin can be found in wheat very often according to **Mesterházy (2007)**. This toxin might be present both in cereals and in processed cereal products, so it is important from the point of food safety **(Hrubošová, 2015)**.

Contrary to data of literature we started from the hypothesis, that nowadays toxin content can be decreased

after harvesting and storing also by application of modern milling industry equipments and technical conditions.

Our first investigations were focused on toxin decreasing effect of Sortex Z+ color sorting machine (Figure 1). This is a new, more precise, quicker technology with less loss in milling processing. It's possible to select the components which size are similar to unbroken, health grain, but they are optically different. The sorting machines applied previously were not satisfactorily efficient to select components which brought down the quality. The manufacturer offers the application of color sorting machine Sortex Z+ as the alternative of the mechanical cleaning equipments. But it possible to gain more efficient sorting than at the mechanical cleaners, and the result is cleaner, contaminants-free product. Color sorting is not yet generally applied in the milling technology. As it was mentioned the application of Sortex Z+ makes possible not just to remove the physical dirt but the grains with different color can be selected also. It is known the color of infected grains can change depending on characteristic and time of infection.

Meteorological factors have significant influence on development of fusarium infection and on degree of toxin content also. The weather conditions are risk factors which can't be influenced during the wheat growing **(Commission recommendation, 2006)**. The prevention against these factors maybe the usage of resistant species. But it is known the species-structure has not changed in the last years in this regard. This means we have to calculate with fusarium infection in the following periods also, especially afterward rainy early summer weather. The degree and the characteristic of fusarium infection depends in which phenology phases was the wheat contaminated. This determines whether just the seed-coat is infected, or the endosperm also. If the weather is favourable for fusarium infection after the fertilization and at the beginning of development of cereal grains, then the rate of cereal grains with fungi in the endosperm is higher. This case the color of grains changes. It becomes bright, primarily greyish-white, but lilac or pinky color might occur also. The color change is very important in the respect of our investigation. In case of early infection a part of wheat grains are smaller and their texture are softer, in parallel with the above mentioned characteristics. As far as the weather becomes rainy in more advanced status of wheat that is at the beginning of the full ripening, then the infection of fungi represents lower rate in the inner part of wheat grain, and the center of infection develops in the layers of seed-coat. In cases of that kind the change of grain color is less typical and the size of grain is not considerably smaller. But the texture of infected grains are softer than the healthy ones. At the end of full ripening the infected seeds barely differ from healthy ones and the inner part of grains remains intact. Accidently mycelium on surface or slight discoloration indicates the infection.

The experimental results of **Hrubošová (2015)** clearly confirm the above mentioned process. The analysis of infected lots of wheat proved there is no correlation between internal and external infection that is they develop independently from each other. Based on the above mentioned results it is difficult to remove the infected seeds from wheat lots after harvest period. It is not possible to decrease the toxin content reliably and efficiently by simple cleaning, selection process. Therefore, scientific literature assumes that the opportunity of decreasing mycotoxin content and thereby the food safety risk is very restricted and uncertain during processing.

Font et al., (2013) implemented model research to decrease DON toxin content, when they created and built machineries in laboratory which were operated similarly to surface cleaning treatment applied in the milling process. The starting hypothesis was that majority of toxin concentrates in the coat and the germ of the wheat. They evaluated the test of a small number of samples which was taken from a given lot of wheat. Their results are important because they proved it is possible to decrease the toxin content of wheat by application certain surface cleaning methods. However, we shouldn't ignore that the degree and characteristic of fusarium infection depends in which phenology phases was the wheat contaminated. This determines whether just the coat and the germ infected or the endosperm affected also. But it shouldn't be ignored that the cleaning treatment and its efficiency is different in mill industrial and in laboratory circumstances due to blending of raw material lots and different processes. Conversely it is very important from food safety aspect to get information not only about theoretical possibilities, but about efficiency of process which actually takes place.

Presumable beyond removing physical dirt the quantity of mycotoxin being the cause of chemical danger can be decreased also. We try to prove the rightness of our hypothesis by our experiments and data.

Toxin-test of wheat harvested in 2013 indicated that the color sorting of grain resulted decrease of toxin content. But the other hand the investigation of the degree of decrease didn't resulted correlation between toxin content before and after color sorting **(Kecskés-Nagy et al., 2015)**. The reason for this is that toxin concentration can be different in the internal layers of the grain depending on the characteristic of the Fusarium infection **(Veha et al., 2015)**. This is why we continued our experiment. We tested wheat samples harvested in 2014 to prove it is possible to decrease toxin level in the mill technology under different ecological circumstances by operation of modern equipment like Sortex Z+ color sorter.

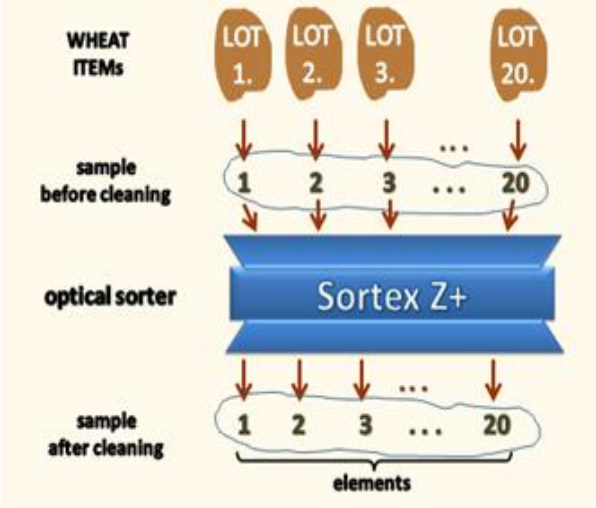

Figure 2 The method of sampling.

MATERIAL AND METHODOLOGY

We carried out the experiment at Júlia Malom Ltd. and investigated the DON toxin content of durum wheat (*Triticum durum*) before and after the cleaning process in the course of milling.

Durum wheat which was the subject of our investigation is cultivated among the wheat species on the second largest territory in the world. It is particularly popular in the mediterranean region. The flour made from hard, glassy wheat grains is used primarily by pasta industry but Sicilians bake bread from that also. Its nutritional value is better than that of *T. aestivum*, which is widely grown in our area. Its consumption is advantageous because of its beta-carotene content, amino acid and protein composition, slowly resorbable carbohydrate content. Owing to its beta-carotene and protein content, pasta can be produced from durum wheat without eggs. But growing experiences indicate that durum wheat is more sensitive to Fusarium infection than other wheat species.

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.

Toxin analysis was carried out in own laboratory of Júlia Malom Ltd with AgraQuant Deoxinyvalenol test kit.

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 analyzed 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 equipment in practice and employed chemical and physical rules. Thus they fulfilled the precondition of normality.

Mathematically we should verify normality with so-called $\chi 2$-probe, but owing to number of data (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.

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:

$$t = \frac{\bar{d}}{s_{\bar{d}}}, \text{ where:}$$

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

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.

RESULTS AND DISCUSSION

Data of initial DON toxin content of wheat can be seen in the Figure 3, 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 analyzed 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_2.

The hypothesis are following:

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

$$\mu_1 > \mu_2$$

In our case the unilateral alternative hypothesis has sense. Figure 3 clearly presents the color sorting have an influence on decreasing of DON toxin content of wheat.

The Table 1 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

$$\alpha=0.0005 \rightarrow t=3.883$$

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

Similarly to examination of wheat samples harvested in 2013, we proved the efficiency of color sorting on decreasing of DON toxin content of wheat in samples cultivated in 2014. The plan of the experiment was started from the results of **Veres and Borbély (2007)** and **Kótai et al., (2012)**. They didn't find correlation between external and internal infection of grains, respectively toxin content. Depending on the characteristic of the infection the toxin concentration might be different in the grain **(Mesterházy, 1995)**. Thus we got to the color sorting method. Using this process principally those grains can be selected, which were infected in early stage of grain development. We come to the conclusion from the examination of results, that color sorting of wheat has statistically verifiable effect on the reduction of toxin content. That is the effect of cleaning is provable on 95% probability level. In this way our experiments proved that the toxin content of wheat can be efficiently decreased by application of modern machinery during the processing. Since this is a food safety question, it is important to clarify the results to what extent can be considered stable and repeatable depending on the different weather conditions of the years. We didn't get unambiguous answer to this. Further investigations are required to determine the extent of correlation between different initial mycotoxin content of wheat before sorting and efficiency of cleaning. Although the efficiency of a Sortex Z+ color sorting machine was justifiable in two very different years with different weather and infection circumstances, but the degree of decreasing of risk is can not be predetermined, because it depends on characteristic of fusarium infection. The grains infected in the full ripening period can not be selected by color sorting, because they are not discolored. In this case DON toxin accumulates in the wheat coat, which becomes bran during the processing. **Sándor et al., (2010)** and **Frank (2010)** investigated the efficiency of traditional surface cleaning in model experiments. Although they experienced different results, these methods had influence on decreasing of DON toxin content. For that very reason we plan to examine a modern surface cleaning method further on. The surface of grain can be cleaned by intense scrubbing machine with good

Table 1 Two sample paired t-probe for probable value.

	DON value before cleaning	DON value after cleaning
Experted value	0.6005	0.5320
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	

Note: Table style: Top and bottom border lines 1.5 point, other lines 1 point.

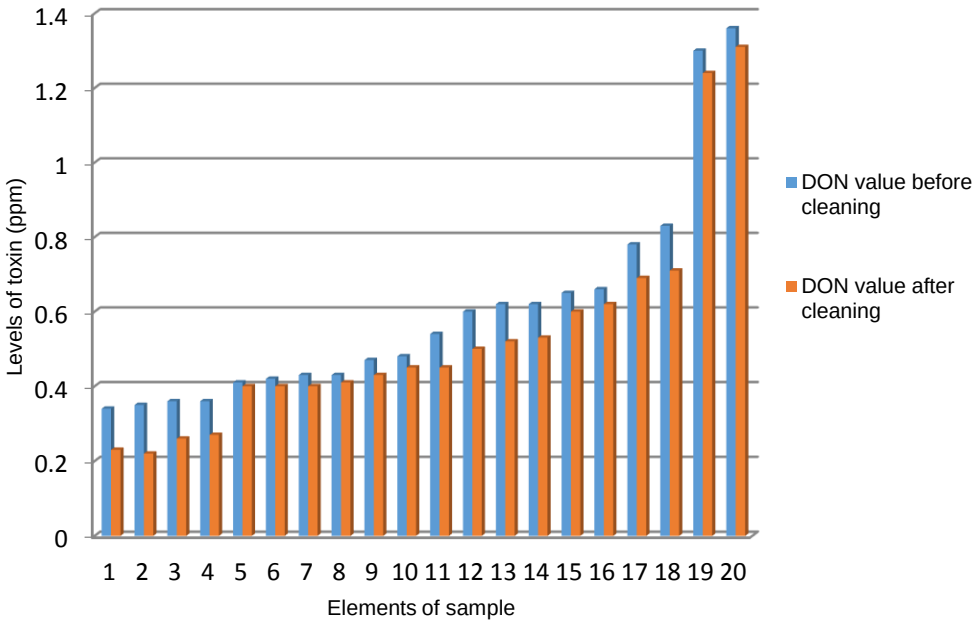

Figure 3 DON-toxin content of wheat before and after cleaning.

efficiency. Júlia Malom Ltd. applies Schule Verticone VPC 480 intense surface cleaner, which is a modern machine. In the next phase of experiment we will examine the efficiency of DON toxin content by application this machine.

CONCLUSION

Requirements of good manufacturing practice (GMP) and good hygiene practice (GHP) must be followed with attention and must be kept in mill industrial production also. On the one hand this means just as instruments and machinery can be applied in production which comply with these requirements. On the other hand it must be kept in mind that by the application of proper machinery in technological process enable to keep the regulation and to decrease risks. For the latter it is good example the opportunity of decreasing of DON toxin during processing. During our research work we prove by experiments, that by applying adequate instruments and machinery the degree of food safety risk can be decreased and the requirements of good manufacturing practice can be fulfilled. 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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