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THE EFFECT OF THE *FUSARIUM* SP. ATTACK ON THE QUALITY PARAMETERS OF ROMANIAN WHEAT

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Abstract

*There have been analyzed 102 samples of Romanian wheat, coming from the crops of the years 2007-2011, in order to assess the influence of the Fusarium sp. attack on the main quality parameters. In this respect, there have been analyzed the following physical and chemical parameters: Hectolitre mass (kg/hl), Moisture (%), Protein content (%), Wet gluten content (%), Falling Number (sec), Gluten deformation (mm), Gluten Index, as well as the Content of kernels attacked by Fusarium (%). The Fusarium attack ranged from 0.1% to 4.5% and was characterized by very high variability. The evaluation of Fusarium attack was made through the Spearman statistical test, which showed its significant influence on the amylase activity of wheat (expressed by the parameter Falling Number, r = -0.22 *) and on the proteolytic activity (expressed by the Gluten deformation, r = -0.28 *).*

Key words**:** *crops quality, Fusarium sp., wheat*

INTRODUCTION

In Romania and in Europe wheat is the most important cereal crop, being grown on an area of about 2 million hectares per year. Most wheat varieties grown in Romania are susceptible to the attack of the following *Fusarium* species: *F. culmorum, F. graminearum* and *F. avenaceum*. Other species reported in Romania are *F. verticillioides, F. oxysporum* and *F. poae*. These species can cause significant crop losses, but the main problem is related to the contamination by mycotoxins (deoxynivalenol, zearalenone, fumonisin, etc.) of the food chains which are based on cereals. Regarding the effect of *Fusarium* attack on the wheat quality, Wang *et al.* (2005) have shown that the addition of a liquid contaminated with *F. culmorum* to the flour, can significantly decrease the Falling Number parameter [1].

Nightingale et al. (1999) have shown through the electron microscopy analysis of wheat grain infected with *Fusarium* sp. that there exist definite zones of endosperm protein degradation. The proteolytic activity caused by *Fusarium* sp. is inhibited by chloromercuribenzoate, and not by the p-trypsin inhibitor from soy, or by the iodoacetic acid, suggesting that the protease in *Fusarium* is an alkaline protease. The rheology studies of dough prepared from the flour obtained from wheat attacked by *Fusarium* showed a decrease of dough consistency and its resistance to extension. Also, the bread made from this flour is characterized by a small volume [2].

Wang et al. (2005) studied protease of *Fusarium culmorum* and identified the optimal range of pH between 6 and 8 and an optimum temperature of 50^0C for the proteasic activity. Protease is still active in the pH range 4.5 to 8.5 and in the range of temperatures 10^0C to 100^0C [3].

Eggert et al. (2011) showed that the *F. graminearum* protease hydrolyzes better the glutenins than the gliadins [4]. *Papoušková et al*. (2011) also showed that the intensity of *Fusarium* attack is related to the deterioration

of dough rheological qualities, evaluated with mixolab. They found a worsening of the mixolabic parameters which are responsible to some extent for the protein quality, especially for the fraction of starch from flour [5]. Considering the importance of the milling and baking industry products to the Romanian people nutrition, we considered useful to undertake a study regarding the effect of *Fusarium* sp. attack on the quality of Romanian wheat, a study based on data collected by us in the last five years.

MATERIAL AND METHOD

We analyzed 102 wheat samples from the crops of the years 2007 to 2011, taken from the Southern Romania, in order to assess the effect of *Fusarium* attack on the baking quality of wheat. For each wheat sample we determined the physical and chemical parameters listed in Table 1, according to the appropriate standards.

Table 1. Methods of analysis used for analyzing the quality parameters of wheat

Quality parameter	Analysis method
Hectolitre mass (HLM, kg/hl)	SR EN ISO 7971-3:2010
Moisture (M, %)	SR EN ISO 712:2010
Protein content (P, %)	ICC 159-95 (NIR method, Perten Inframatic 8600)
Wet gluten (WG, %)	SR EN ISO 21415-2:2008
Gluten deformation (GD, mm)	SR 90:2007
Gluten Index (GI)	ICC 155-94
Falling Number (FN, sec)	SR EN ISO 3093:2010

The attack by *Fusarium* sp. has been estimated using the parameter Content of kernels attacked by *Fusarium*, according to the method described by ISO 7970 and expressed in percentage by weight. Additionally, we determined for the analyzed samples the Content of kernels attacked by *Eurygaster* sp. (KAE, %), determined according to ISO 7970. The results were interpreted statistically, using a specific software, StatSoft, Inc.. (2004), STATISTICS (Data Analysis Software System), version 7, www.statsoft.com).

RESULTS AND DISCUSSIONS

The results obtained by determining the quality parameters for the 102 analyzed wheat samples are presented in Table 2, using the following variability estimates: the arithmetic mean (X), the standard deviation (Sx) and the coefficient of variation (CV).

Table 2. Estimates of variability for the wheat samples

Quality Parameters	$X \pm s_x$	CV (%)
HLM (kg/hl)	75.684 ± 2.968	3.921
M (%)	12.753 ± 0.871	6.830
P (%)	13.924 ± 2.004	14.392
WG (%)	30.065 ± 6.586	21.906
GD (mm)	9.396 ± 7.308	77.778
GI	41.344 ± 25.221	61.003
FN (sec)	315.147 ± 81.929	26.000
KAF (%)	0.520 ± 0.746	143.461
KAE (%)	2.021 ± 2.706	133.89

In Table 2 we can see that the heterogeneity regarding the areas and the years of wheat samples induced a significant increase of the coefficients of variability of certain quality parameters. Thus, while for the parameters for Hectolitre mass, Moisture, Protein content and even Wet gluten content, the variability coefficients can be considered as being normal, for the parameters describing the enzymatic activity (Falling Number, Gluten deformation and Gluten Index) the values of the coefficients of variability were high and very high.

Special cases were represented by the percentage of kernels attacked by *Fusarium*, where the coefficients of variability exceeded by almost 50% the average value and the percentage of kernels attacked by *Eurigaster* sp. (34%).

Given the excessive variability of some quality parameters, especially for the Content of kernels attacked by *Fusarium*, we had apply a series of statistical tests, in order to check the normality of the distribution. Thus, we studied the links between variables, taking into consideration nonparametric statistical methods.

Table 3 presents the results of the test Kolomorogov-Smirnov (KS), in order to check the normal distribution of the quality parameters of wheat samples (where n - number of analyzed samples; max.D - specific estimator of KS test for the difference between the two distributions, p - probability of transgression for the values of D estimator, corresponding to the following significance levels: 0.05 - significant, 0.01 - very significant, distinct significant 0.001).

Table 3. *Kolomorogov-Smirnov* test (normality of data distribution), for the quality parameters of wheat

Parameter	max D	K-S - p
HLM (kg/hl)	0.102	p > 0.20
M (%)	0.132	p < 0.10
FN (sec)	0.112	p < 0.20
P (%)	0.090	p > 0.20
WG (%)	0.107	p > 0.20
GD (mm)	**0.217**	**p < 0.01**
KAF (%)	**0.287**	**p < 0.01**
KAE (%)	**0.239**	**p < 0.01**
GI	0.122	p < 0.15

Table 3 shows that distribution of the values of Gluten deformation, Content of kernels attacked by *Fusarium* and Content of kernels attacked by *Eurygaster* sp. differ significantly from the normal distribution curve. Other quality parameters of wheat are characterized by values that are not significantly different from the theoretical distribution. Given the results for these three parameters we consider arithmetical averages and standard deviations (Table 2) as being unrepresentative in terms of central tendency. Most suitable are other estimators of central tendency, such as median and module (Table 4).

Table 4. Median and module of wheat quality parameters, which were not normally distributed

Parameter	Median	Module
GD (mm)	6.5	4
KAF (%)	0.2	0.1
KAE (%)	1.0	0.2

Table 5 presents the Spearman correlation coefficients, which describe the relationships between the quality parameters of wheat.

Table 5 shows that **the Percentage of kernels attacked by *Fusarium* does not significantly influence the Hectolitre mass and the Protein content**, ie **Gluten**, in wheat. Also, the percentage of kernels attacked by *Fusarium* is not significantly correlated with Moisture of grains.

The percentage of kernels attacked by *Fusarium* significantly affects the amylase activity of wheat, measured by the Falling Number parameter. Basically, **as the percentage of kernels damaged by *Fusarium* grows, the Falling Number decreases** with the same amount (the amylase activity increases). This phenomenon is likely the result of the action of the enzymatic equipment, rich in amylase, with which fungus attacks the substrate (wheat kernel endosperm). Although, some studies in the literature have suggested that the Falling Number method would not be appropriate for evaluating the quality of wheat *Fusarium* attack (*Wang et al.*, 2008), our results show a minor but significant impact of the attack of *Fusarium* on this parameter [6]. Approximately 5% of the variability of Falling Number is due to the *Fusarium* attack, according to the results of our study ($r^2 = 4.84$). **The percentage of kernels attacked by *Fusarium* was significantly negatively correlated with the Gluten deformation of wheat.** Apparently, our results suggest that *Fusarium* attack decreases the proteolytic activity expressed by the Gluten deformation. Results are in conflict with some observations in the literature, describing the effects of attack by *Fusarium* sp. on the proteolytic activity of wheat. Our results (the decreasing of the proteolytic activity with the increasing of the Percentage of kernels attacked by *Fusarium*), support the hypothesis of ecological relationships between *Fusarium* sp. and the insects, whose attack is responsible to a large extent of the proteolytic activity of wheat (*Eurygaster* sp.).

Literature refers to entomopathology cases caused by *Fusarium* sp. and *Beauvaria bassiana* at species of the genus *Eurygaster*. Thus, Assaf *et al.* (2011) quoting Ali (1995) and Mohamad (2000), referr to a series of studies which show a mortality of 80% to *E. integriceps*, induced by the mentioned species of fungi [7].

In a literature review, *Sandhu et al.* (2012) considered the *Fusarium* and *Aspergillus* fungi as facultative pathogens and general (nonspecific) pathogens of insects [8].

Table 5. *Spearman* correlation coefficients, between the quality parameters and their significance

Pairs	*HLM*	*M*	*FN*	*P*	*WG*	*GD*	*KAF*	*GI*	*KAE*
HLM	1.00								
M	-0.12	1.00							
FN	0.30	-0.34	1.00						
P	-0.40	-0.31	-0.04	1.00					
WG	-0.28	-0.28	-0.11	0.93	1.00				
GD	-0.19	-0.30	0.24	0.28	0.14	1.00			
KAF	**0.01**	**0.004**	**-0.22**	**-0.001**	**0.07**	**-0.28**	**1.00**		
GI	0.24	-0.15	0.05	-0.29	-0.24	-0.46	0.10	1.00	
KAE	-0.37	-0.22	-0.02	0.44	0.31	0.73	**0.305**	-0.36	1.00

Basically, at least partially attack of *Fusarium* induces a reduction of wheat bug attack (*Eurygaster* sp.), a phenomenon that is expressed through a reduction in proteolytic activity of wheat.

The result of *Spearman* correlation test showed that between the Percentage of kernels attacked by *Fusarium* and the Percentage of kernels damaged by wheat bug, there is a significant negative correlation (r = -0.305 *). Practically, the higher the degree of *Fusarium* attack, the lower the degree of bug attack. We also note that the coefficient of correlation between the two parameters is very close to the coefficient of correlation between parameters Content of kernels attacked by *Fusarium* and Gluten deformation (r = -0.280 *).

We believe that in light of the literature, the existence of correlations is justifying the assumption of **a fungus - insect interaction**, which is highlighted in values of proteolytic activity of wheat, expressed by the Gluten deformation.

CONCLUSIONS

Our results show that the *Fusarium* attack, expressed by Content of kernels attacked by *Fusarium* parameter, did not significantly affect the Falling Number, Moisture, Protein content and Gluten Index of wheat.

The *Fusarium* attack causes a minor decrease of the parameter Falling Number, as a consequence of the amylase brought by the fungus in the wheat endosperm. *Fusarium* attack caused a decrease in proteolytic activity in wheat samples, probably due to entomopathological effect of fungus on insects of the genus *Eurygaster* sp.

Our hypothesis is confirmed by the existence of a significant correlation between the percentage of kernels attacked by *Fusarium* and the percentage of kernels damaged by wheat bug.

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