Current Trends in Natural Sciences Vol. 6, Issue 11, pp. 29-34, 2017

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

THE EFFECT OF INSECT DAMAGED KERNELS (IDK) AND SPROUTED WHEAT KERNELS (SWK) PARAMETERS ON BAKERY PROPERTIES OF SOME ROMANIAN WHEAT SAMPLES

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Abstract
*It had been analyzed the impact of two key parameters, namely insect damaged kernels (IDK) and sprouted wheat kernels (SWK), on quality parameters of Romanian wheat samples from 2016 harvest. The results showed that IDK had a significant influence on all the quality parameters of wheat, with the exception of Falling Number. The increase of IDK very significant decreased the values of: Hectolitric mass (r = - 0.407 ***), Moisture (r = - 0.263 **), Gluten Index (r = 0.297 **) and increased very significant the values of Protein content (r = 0.477 ***), Wet gluten (r = 0.398 ***) and Gluten deformation index (r = 0.620 ***). SWK was correlated negative very significant with Falling Number (r = -0.602 ***) and positive significant with Moisture (r = 0.294 *). Also, between IDK and SWK it was established a significant negative correlation (r = -0.337 *). The results showed that the two parameters had a notable influence on the enzymatic activity of wheat. Thus, IDK significantly influenced proteolytic activity, while SWK significantly influenced amylolytic activity. Higher values than 3% for IDK parameter and respectively 4.5% for SWK parameter led to gradual loss of the bakery qualities of analyzed wheat samples.*

Keywords: insect damaged kernels, quality parameters, sprouted wheat kernels, wheat.

1. INTRODUCTION

Wheat crops and agriculture in general is dependent on climatic conditions, which are in constant change in the last century, change which threatens to become dramatic. Global warming and changes of rainfall patterns alter the dynamics of pests world population and also the resistance of crops to pests. Yield losses due to attack of pests and diseases are a serious threat to global food security, but also to the sustainability of small businesses in rural areas (Savary et al., 2014; Avelino et al., 2015). Economic losses caused by disease, pests and unsuitable weather conditions at harvesting are unpredictable and difficult to control. Losses can be direct, correlated to the amount of grain, but also indirect, due to deterioration of the harvest quality (Oerke, 2006; Cerda et al., 2017). These losses can be as high as 40% of the crop total amount (Oerke et al., 1994).

In this paper we analyzed the impact of two key parameters, correlated with the attack of pests and environmental conditions during harvesting (insect damaged kernels IDK and sprouted wheat kernels SWK), on quality parameters of some Romanian wheat samples, harvest year 2016.

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Insect damaged kernels IDK are wheat kernels which show a visible degradation with the naked eye, due to the attack of rodents, insects, mites or other pests.
Sprouted wheat kernels SWK are wheat kernels showing a sprouting start. Normally, this parameter has to be correlated, according to the standard, the value of amylolytic activity, expressed by the Falling Number parameter.
The aim of our study was to highlight this correlation, considering that amylolytic activity, induced by germination is dependent on the advancement of SWK values. Also, our study aims to highlight the significance of IDK influence on proteolytic activity (Tamba-Berehoiu et al., 2012).

2. MATERIALS AND METHODS

There were analyzed 102 samples of Romanian wheat, 2016 harvest, in terms of quality parameters, which are shown in Table 1.

Table 1. Quality parameters and analysis methods used

Quality parameters	Analysis methods
Hectolitric mass (MH, kg/hl)	*STAS 6123/2-73*
Moisture (M, %)	*SR ISO 712/1999*
Protein content (P, %)	*ICC 159-95 (NIR method, Perten Inframatic 8600)*
Wet gluten (WG, %)	*SR ISO 21415-2:2007*
Gluten deformation index (GDI, mm)	*SR ISO 21415-2:2007*
Gluten Index (GI)	*ICC 155-94*
Falling number (FN, s)	*SR ISO 3093:2005*
Insect damaged kernels (IDK, %)	*SR ISO 7979: 2001*
Sprouted wheat kernels (SWK, %)	

The results were statistically interpreted using professional specific software, IBM SPSS Statistics v. 20.

3. RESULTS AND DISCUSSIONS

The mean values of quality parameters for Romanian wheat samples, as well as the estimates of variability are presented in Table 2.

Table 2. Mean values and variability estimates of quality parameters

Specification	Minimum	Maximum	Mean	Std. Deviation	Variation coefficient (%)
MH (kg/hl)	65.40	82.40	75.633	3.002	3.969
M (%)	10.43	15.88	12.758	0.875	6.858
FN (s)	62.00	441.00	313.569	82.508	26.312
P (%)	9.94	20.01	13.963	2.005	14.359
WG (%)	16.70	47.58	30.131	6.588	21.864
GDI (mm)	1.50	32.50	9.322	7.310	78.417
IDK (%)	0.20	20.50	3.634	4.252	117.001
GI	2.00	91.00	41.621	25.207	61.284
SWK (%)	0.10	7.40	0.899	1.665	185.205

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From Table 2 it is observed that the analyzed samples were characterized by a large variability of the quality parameters. Except Hectolitric mass, Moisture and Protein content, all the other parameters had the values of variation coefficients higher than 14%.
In the case of IDK and SWK parameters, the values of variation coefficients exceeded 100%.
The mean values of quality parameters were generally, within the limits provided by the literature for bakery wheat. Thus, hectolitric mass parameter had a mean value placed at the lower limit agreed in industrial technical specifications (75.63 kg/hl to min 76 kg/hl). Moisture parameter was characterized of a mean value of less than 14.5%. Falling number, protein and wet gluten content parameters had on average, optimal values for bakery. Gluten deformation index parameter had a relatively high mean value (9.32 mm), suggesting the existence of a significant proteolytic activity, which affected the quality of gluten. Proteolytic activity appeared to be responsible for the reduced value of gluten index parameter (41.62 to 60 min). The value of this parameter suggested that the gluten was characterized by a reduced capacity for gas retention and tenacity lack.
It is seen from the table that the variation ranges of analyzed quality parameters included samples with values located to extremes. For example, a sample with a falling number of 62 s is not suitable for bakery, due to excessive amylolytic activity. Also, values of 30 mm for gluten index deformation, or values of 2 for gluten index parameter, indicated an intense proteolytic activity incompatible with bakery qualities.
Due to the excessive variability of the quality parameters we opted for an evaluation of links between the variables, by Spearman's rank correlation analysis.
The results are shown in Table 3. In the table was mentioned the number of samples entered in the calculation of correlation coefficients, for each pair of parameters.

Table 3. Spearman correlation coefficients and their significance

PAIRS	MH	M	FN	P	WG	GDI	IDK	SWK	GI
MH	1.000 n=102								
M	-0.142 n=102	1.000 n=102							
FN	0.322*** n=102	-0.355*** n= 102	1.000						
P	-0.402*** n =102	-0.280** n = 102	-0.035	1.000					
WG	-0.276** n = 95	-0.266** n = 95	-0.093	0.934*** n = 95	1.000				
GDI	-0.192	-0.311** n = 95	0.232* n = 95	0.293** n = 95	0.159	1.000			
IDK	**-0.407***** n = 101	**-0.263**** n = 101	-0.007	**0.477***** n = 101	**0.398***** n = 94	**0.620***** n = 94	**1.000**		
SWK	-0.259	**0.294*** n = 56	**-0.602***** n = 56	0.097	0.012	-0.250	**-0.337*** n = 56	**1.000**	
GI	0.243* n = 95	-0.138	0.058	-0.311** n = 95	-0.256* n = 95	-0.447*** n = 95	**-0.297**** n = 94	-0.066	1.000

** Correlation is significant at the 0.05 level (2-tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*
**** Correlation is significant at the 0.001 level (2-tailed)*

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In Table 3 we see that IDK parameter had a significant influence on all quality parameters, with the exception of Falling Number.
The increase of IDK content decreased very significant the hectolitric mass (r = - 0.407 ***), distinct significant the moisture (r = - 0.263 **) and the gluten index (r = -0.297 **) and increased very significant the protein content (r = 0.477 ***), wet gluten (r = 0.398 ***) and gluten deformation index (r = 0.620 ***). The effect on the hectolitric mass was probably due to a reduction of the specific weight of wheat, as a result of consumption of a kernel part by the insects. At the same time, the shape of kernels changes, phenomenon that affects its behavior at compaction. The effect over the moisture parameter could be explained by the compromising of the kernels integrity, namely the natural barriers against dehydration, respectively the increase of moisture exchange surfaces with the environment.
Increased protein content in cereals with a higher content of IDK can have various explanations. On one hand, the excessive consumption of endosperm (starch-rich) by insects, lead to the fact that the proteic fraction of kernel, most prominently in the aleurone layer, acquires greater importance concerning the mass of whole kernel. Not to be neglected here, nor the direct contributions of pests populations: saliva enzymatic equipments or even metabolites (manure) remaining in/on wheat kernels.
The effects on wet gluten content should be discussed in relation to the observed effects on the quality of the gluten. This is important, because the kernel gluten fraction is represented by a mixture of proteins, mechanical separable from the starch, in a stream of 2% sodium chloride solution. Mechanical properties of separated gluten, depend on wheat proteolytic activity. Thus, gluten derived from wheat with high proteolytic activity is very sticky, difficult to separate from starch or hemicellulose (bran) and the separation is incomplete.
As seen in Table 3, the proteolytic activity, as it is expressed by gluten deformation index, significantly increased with the increase of IDK value. This effect was confirmed by the significant decrease of gluten index parameter. The phenomenon is explained by the remanence of proteolytic equipments of the insects saliva in wheat kernels. These proteases continue working, leading to deterioration of the gluten quality.
Figure 1 shows schematically the variation of the mean value of gluten deformation index at different variation ranges of IDK content. Note that as IDK content grew, the gluten deformation index also grew.
The data presented in Figure 1 showed that the proteolytic activity was accelerated beyond the range of 0-3% IDK.

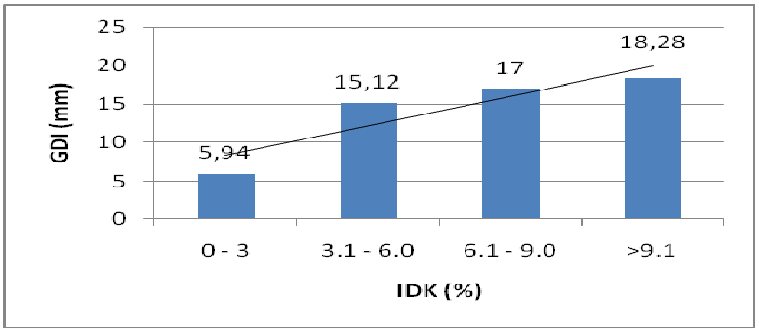

Figure 1. The relationship between IDK and wheat gluten deformation Index

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In Figure 2 the same presentation is made, but for Gluten index parameter. A similar trend could be observed regarding gluten index parameter, whose value decreased with the increase of IDK percentage. Gluten index parameter decrease was slightly less steeper compared with the increase of deformation index. This is probably due to the fact that in the value of this parameter is involved factors related to the genetic potential of wheat samples varieties, not only the proteolytic activity. A proof of this was represented by the fact that in the IDK range of 0-3%, the mean value of gluten index (48.81) is already quite low, compared to the bakery standards mentioned in literature (60 min).

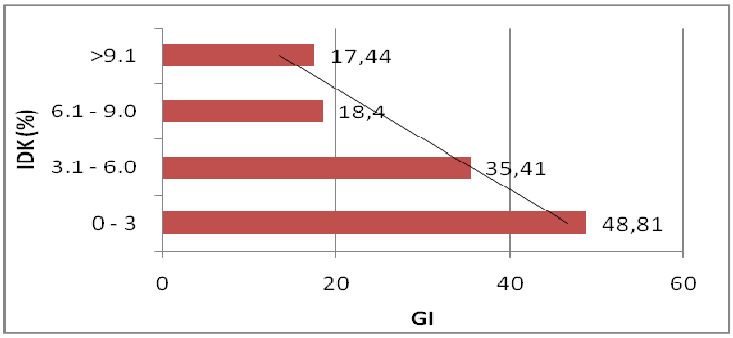

Figure 2. The relationship between wheat IDK content and Gluten index parameter

From Table 2 it can be seen that IDK parameter correlated very significant negative with Falling Number parameter (r = -0.602 ***), and significant positive with the value of Moisture parameter (r = 0.294 *). Also, it was observed that between the two analyzed parameters, namely IDK and SWK, there was a significant negative correlation (r = -0.337 *). Wheat amylolytic activity, expressed by Falling number parameter increased very distinct significant with the increase of the SWK amount (r = 0.602 ***).

From Figure 2 is seen that the increase of the amylolytic activity (decrease of the Falling Number parameter value) was accentuated for proportions of more than 3% SWK. On average, an increasing proportion of SWK, higher than 4.5%, resulted in a complete loss of wheat bakery qualities (the optimal bakery qualities value of Falling number parameter is 200 s). This is an important aspect in assessing the wheat quality, as amylolytic activity of wheat is conserved in flour and is very difficult to correct in bakery technology.

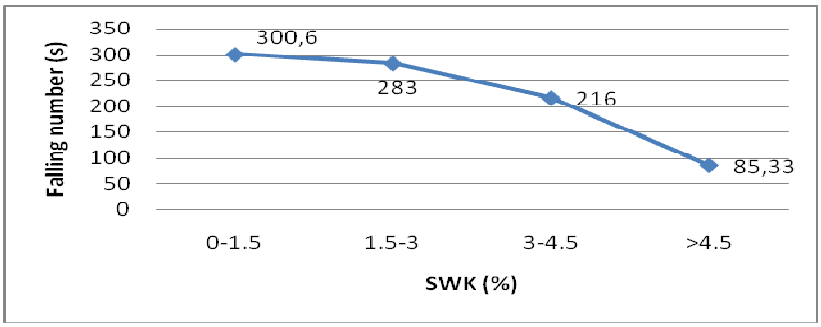

Figure 3. The relationship between wheat SWK content and Falling number parameter

From the results you can see how important climatic factors are, in improving the quality of crops. On one hand, atmospheric moisture (rainfall) during the harvesting, promotes the germination of

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grains in the ear, having an effect on the growth of the wheat amylase activity (as reflected by Falling number parameter). In Table 3 it can be seen moreover, that between SWK parameter and wheat Moisture had been established a positive significant correlation (r = 0.294 *). On the other hand, the amplitude of pests attack is determined not only by climatic factors, but also by phytotechnical factors.

4. CONCLUSIONS

The analyzed samples were characterized by a high variability of quality parameters. Except Hectolitric mass, Moisture and Protein content, all other parameters had higher variation coefficients than 14%. For IDK (**I**nsect **D**amaged **Kernels)** and SWK (**Sprouted W**heat **K**ernels**)** parameters, variation coefficients values exceeded 100%.

The mean values of quality parameters were generally, within the limits set by the literature for bakery wheat.

IDK parameter had a significant influence on all quality parameters, with the exception of Falling Number. The increase of IDK determined the very significant decrease of Hectolitric mass (r = - 0.407 ***), Moisture (r = - 0.263 **), Gluten index (r = 0.297 **) and the the very significant increase of Protein (r = 0.477 ***), Wet gluten (r = 0.398 ***) and Gluten deformation index (r = 0.620 ***).

IDK parameter had a significant influence on the proteolytic activity of wheat, as expressed by Gluten deformation index and Gluten index. IDK values above 3% led to the increase of proteolytic activity, beyond the limits to which the quality of gluten allows the obtaining of flour with good bakery qualities.

SWK parameter correlated distinctive significant negative with Falling Number parameter (r = - 0.602 **), and significant positive with Moisture parameter value (r = 0.294 *). SWK parameter had a significant influence on the amylolytic activity, since at levels higher than 4.5%, the wheat downgraded from bakery qualities.

The results showed the very importance of environmental and technological factors, in terms of overall crop quality formation.

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*** *ICC 155-94*
*** *ICC 159-95*
*** *SR ISO 21415-2:2007*
*** *SR ISO 3093:2005*
*** *SR ISO 712/1999*
*** *SR ISO 7979: 2001*
*** *STAS 6123/2-73*

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