CHANGES OF WHEAT QUALITY CAUSED BY MOLD CONTAMINATION

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Abstract

Great importance for the wheat flour/dough quality besides the content and quality of gluten proteins, also have starch and the enzymatic activity. The sprouted kernels can change wheat enzymatic activity and worse the bread making quality.

The aim of this study was the presence of field molds in wheat kernel and flour of the most spread out wheat varieties in domestic production to be determined, as well as to investigate their enzymatic activity.

Three wheat varieties of Triticum aestivum, which kernels on the basis of sensory, mycological and toxicological investigations were classified into three kernel fractions: sound, “little fusarious” and “much fusarious” kernels. Quantitative and qualitative microbiological analyses were performed on the wheat kernels in order the mold contamination to be determined. The enzymatic activity was comparatively investigated according to Berliner swelling number, the amylolytic number and Hagberg falling number.

The results obtained from the investigations have shown that there were differences in the enzymatic activity of the wheat fractions contaminated with Fusarium spp., i.e. it was increased with the contaminated fractions compared to the sound one. So, the average value of the Hagberg falling number for the “little fusarious” kernels was smaller for 7.0-2.0%, while for the “much fusarious” kernels it was smaller for 35 - 40%.

With the fraction “little fusarious” kernels the average decreasing of Berliner number was in the range 22 - 35%, and with the fraction “much fusarious” kernels was smaller for 60 - 70%.

The value of the amylolytic number has also decreased, which in average ranged from 35 to 40% with the fraction “little fusarious” kernels, and for 45 - 55% with the fraction “much fusarious” kernels.

Key words: Wheat, Variety, Enzyme activity, Mycotoxins, Fusarium spp.

1. Introduction

Cereals, especially the wheat as the basic bread cereal, represent an important strategic row material for the nutrition of the nation and domestic animals. The wheat and all its products can be contaminated by molds at all phases of the production chain. Many of those molds are toxic being potential producers of various mycotoxins with harmful consequences for the health of the population and domestic animals [1]. According to the references provided by Jovichevic [2] and Sharic et al. [3], during vegetation there is a possibility for mold to grow together with wheat, and around 80% of the contaminated kernels are attacked by the molds. Mycotoxins decrease the technological quality of cereals causing economical losses [4 and 5].

The wheat mixture coming at the reception acceptance in the processing industry very often contains besides the sound also contaminated kernels. It is unknown which ratio of contaminated kernel fractions is processed into a certain type of flour at the mill, or as a feed component for animal feed, continuing into the final products which are consumed by the population and domestic animals. There is a need for application of new techniques for fast determination of the contamination with mycotoxins of cereals/feed that can be enabled for fast and qualitative/quantitative determination of the contamination, with an aim on time preventive measures to be taken for avoiding the harmful consequences on the health of the animals and population [6].

All kernel constituents have influence on the wheat quality [7]. As the most abundant wheat component starch has an important role for the human nutrition in bread production, on one side, as well as for the animal nutrition on the other side [8]. It is based on its ability for water absorption, as well as the viscosity and
dough consistence. On the dough properties an influence also has the dimension of the starch kernels as well as the degree of their damage during the wheat milling. Starch damage and α-amylase activity which were determined in the milled flour of different milling fractions of domestic wheat varieties, vary, what is in accordance with the milling process and wheat genotype, as described by Menkovska [7].

The diastatic power of flour, including the power for sugar forming and clusterisation of starch, is important for flour technological quality. Starch clusterisation in dough occurs in water at higher temperatures in presence of the enzyme diastase, what has an influence on the sugar forming. At this moment, the starch is transformed from a crystal shape into gel i.e. in a clusterised form, while a change of the starch suspension viscosity is occurring. The sugars in dough are formed by degradation of the molecules of amylase and amylpectin by the enzymes α- and β-amylases, which degrade starch to maltose (by β-amylase) and to maltose and dextrin (by α-amylase). The α-amylase acts to 1-4 and to 1-6 bonds at any place in the starch molecule.

The ability of starch clusterisation in suspension is determined by the amylograph, the dynamic rotational viscosimeter, as well as by the falling number, and the two methods measure the relative viscosity, i.e. the α-amylase activity.

We have already published the results obtained from the investigations on the influence of wheat mold contamination on its physical-chemical quality, and on the reological quality, respectively [9 and 10]. In thus study we present the results from the investigations on the amylolytic and proteolytic enzyme activity of contaminated wheat with Fusarium spp., undertaken with an aim to investigate the presence of molds in the wheat kernel and flour with identification of the species from the isolated micropopulations, first of all of the toxic species.

In the conclusions we have pointed out that the field molds decompose the wheat kernel causing decreasing of its biological and processing quality what has resulted in increasing of the enzymatic activity.

2. Materials and Methods

Tree wheat varieties were investigated in this study: Milenka, Radika and Bistra, which were grown within the frame of a two years field micro-experiment undertaken on the Belimbegovo locality, Skopje region, in collaboration with the Agency for agricultural development - Regional Center Skopje.

According to Jovichevic [2] the contaminated kernels are classified into “little fusarious” and “much fusarious” kernels. In the first group are less shrunken kernels with less white or pink colour, and these kernels are contaminated during the latest development phase, at he end of the milky maturity. In the second group belong the kernesles which are much pale-red or white and expressivly shrunken kernels, which are contaminated during the early development phase, at the beginig of the plant flouring and ear forming.

In our investigations the wheat kernels were fractionated into three groups on the basis of a sensorial evaluation, as well as of mycological and toxicological check: the 1st group is named sound, (sound, non-contaminated kernels by Fusarium spp., as a control group), the 2nd group - “little fusarious” kernels, and the 3rd group - “much fusarious” kernels.

The enzymatic activity was determined on the average wheat samples by tree methods: Hagberg falling number according to the standard ICC method of analysis [11], the gluten swelling method according to Berliner, as well as the amylolytic number, according to ICC standard methods [11], and to Kaludjerski and Filipovic [12].

The mycological analyses were determined as was described by Sharic et al. [3].

Mycotoxins (ochratoxin - OTA and zearalenon - ZEA) quantitatively and qualitatively were analyzed by thin layer chromatography (TLC) according to ICC standard method [11].

3. Results and Discussion

Changes of kernel technological quality-enzymatic activity

The results obtained from the investigations on the enzymatic activity of the wheat varieties, as well as from the mycological and toxicological analyses, were presented in Tables 1 - 3. They have shown that with the fraction of sound kernels, the flour has small enzymatic activity (Table 1). This can be seen from the high values of the amylolytic activity which ranges from 410 to 450 AE as well as from the high values of the Hagberg falling number, which ranges from 300 to 350 units. The satisfying values which correspond to the flour from our region are in the range from 350 to 500 AE (amylograph units).

As it can be seen from the Table 1, with the fractions contaminated by Fusarium spp. the enzymatic activity increases, i.e. the value of the amylolytic number decreases, which in average range from 35 to 40% with the fraction “little fusarious” kernels comparing to the sound kernels. Higher enzymatic activity was noticed with the fraction “much fusarious” kernels, i.e. the amylolytic number is smaller for 45 - 55%.

The similar tendency for decreasing of the Hagberg falling number was noticed with the kernels contami-
nated with *Fusarium* spp. With the fraction “little fuzarious” this number is smaller in average for 7.0 - 20.0% comparing to the sound kernels. Significant decrease of this number is noticed with the fraction “much fuzarious” kernels which in average was smaller for 35 - 40%.

Using the gluten swelling method according to Berliner, the influence of proteolytic enzymes in flour can be determined. Based on this quality indicator, our results have shown that with the fraction “little fuzarious” kernels the average decreasing of this number was from 22 to 35% comparing to that of the sound kernels. The flour enzymatic activity has increased in that extent what was the decreasing of this number. With the fraction “much fuzarious” kernels the Berliner number was smaller for 60 - 70% comparing to that of the sound kernel fraction.

### Changes of kernel microbiological quality

By a quantitative and qualitative microbiological analysis on wheat samples (Table 2) the mold species were determined by which the wheat samples were contaminated with.

#### Table 2. The total number of mold microorganisms and particular genus

<table>
<thead>
<tr>
<th>Kernel fraction</th>
<th>Total mold number</th>
<th>Index</th>
<th>Identified mold genus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound</td>
<td>11300</td>
<td>100.0</td>
<td>Mucor, Penicillium</td>
</tr>
<tr>
<td>Little fuzarious</td>
<td>96000</td>
<td>849.0</td>
<td>Fusarium, Mucor, Penicillium</td>
</tr>
<tr>
<td>Much fuzarious</td>
<td>286000</td>
<td>1646.0</td>
<td>Fusarium, Mucor</td>
</tr>
<tr>
<td>Average</td>
<td>154000</td>
<td>13628.0</td>
<td>Fusarium, Mucor, Penicillium</td>
</tr>
</tbody>
</table>

With the microbiological investigations was confirmed the sensory estimate for the presence of *Fusarium* spp. in the kernel fractions of the average kernel sample. Our investigations have shown that with the two wheat contaminated kernel fractions were present mold microorganisms (Table 2). The most present were the microorganisms of the genus *Fusarium*, while less present were the microorganisms from the genus *Penicillium*. The high level of contamination with *Fusarium* spp. resulted in the existence of great number of strains of these molds which exist in natural conditions.

In Table 3 the results from toxicological investigations on the all kernel fractions are presented, which were undertaken with an aim the degree of contamination with mycotoxins to be determined.

#### Table 3. Contamination of kernel fractions with mycotoxins (average values)

<table>
<thead>
<tr>
<th>Kernel fraction</th>
<th>Mycotoxins (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OTA</td>
</tr>
<tr>
<td>Sound</td>
<td>-</td>
</tr>
<tr>
<td>Little fuzarious</td>
<td>16.00</td>
</tr>
<tr>
<td>Much fuzarious</td>
<td>30.00</td>
</tr>
<tr>
<td>Allowed limits</td>
<td>5.00</td>
</tr>
</tbody>
</table>

The results presented in Table 3 have shown that high contamination has appeared in the two fuzarious kernel fractions, in regard to the sound fraction. The toxicological analysis has determined the presence of mycotoxins in the two fuzarious kernel fractions. ZEA with the “much fuzarious” fraction was present above the allowed limits prescribed with the European regulations, while OTA in the two fuzarious fractions had much higher value above the allowed limits. According to the Regulations of the European Commission [13] for the maximal allowed quantities of particular contaminants in food, for the all unprocessed cereals with the exclusion of corn, including rice and rice products, the maximum allowed value for ZEA is 100 µg/kg. For bread, including the small baked products, biscuits, snack products and breakfast cereals with the exclusion of corn products, this value is 50 µg/ kg. For processed food based on cereals with the exclusion of...
corn, as well as the baby food and food for small infants, the maximum allowed value of ZEA is 20 μg/kg. As for OTA, for unprocessed cereals the maximum allowed value is 5.0 μg/kg, while for the products is 3.0 μg/kg. As for DON, with the exclusion of durum, oat and corn, for the unprocessed cereals the maximal allowed value is 1250 μg/kg. In our country the EU Regulation is introduced according to the Regulation for the common application for food safety [14]. Regulations in the field of food safety and quality in Republic of Macedonia are in accordance with the Euro regulations [15].

4. Conclusions

As a consequence of the decomposition of the wheat kernel due to mold contamination by the genus Fusarium, it can be concluded that the enzymatic activity of the contaminated kernel fractions compared to that of the sound kernels was increased as follows:

- The average value of the Hagberg falling number for the "little fusarious" kernels was smaller for 7.0 - 2.0%, while for the “much fusarious” kernels it was smaller for 35 - 40%.
- With the fraction “little fusarious” kernels the average decreasing of Berliner number was in the range from 22 to 35%. With the fraction “much fusarious” kernels the Berliner number was smaller for 60 - 70%.
- The value of the amylolytic number has also decreased, which in average ranged from 35 to 40% with the fraction “little fusarious” kernels. Higher enzymatic activity was noticed with the fraction “much fusarious” kernels, i.e. the amylolytic number was smaller for 45 - 55%.
- In order quality and safety of wheat and wheat products to be maintained and prevention from contamination by Fusarium spp. to be undertaken at all phases of the food chain, a quality preventive system and quality managing should be introduced according to the accepted European standards for quality and safety food production. It is also necessary to develop new analytical methods for fast and accurate control of the safety status of cereals and their products.
- Further investigations should be also undertaken on the safety and hygienic assurance of different cereals, as well as on the feed, including their monitoring in our country according to the European standards.

5. References