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Variation of the nutritional components of stored maize, due to the influence of insects from the *Sitophilus* complex (*S. oryzae* and *S. zeamais*) infestation and resultant fungal development

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Abstract

An experiment was conduced on stored maize grain to evaluate the effects of *Sithophilus oryzae* and *Sithophilus zeamais* infestation on Calcium, Nitrogen, Phosphorus, Potassium, Magnesium, and total protein. There were four treatments: Forty kilos separated in two portions of 20 kilos containing low moisture maize (13.5 % RU) with and without insects, and in the same proportion high moisture maize (22.0 % RU), with and without insects. All the treatments were repeated 4 times using 5 kilos of maize. In the insect infested portions were released 20 adults of the complex *Sitophilus*, (*S. oryzae* and *S. zeamais*) originally from populations collected at Paraná State. Nutritional value of the grain was evaluated after 0, 30, 60, 90, 120, and 150 days of storage. Regression analysis was used to analyze changes in nutritional value of the maize over time. Nitrogen and Protein content increased in the treatments of low-moisture maize, with and without insects and in the high-moisture maize with insects during storage. Phosphorus amount ranged from 0.65 % to 0.15 % during the storage period. The Potassium content fell from 0.40 % to 0.15 % during storage. Calcium content fell from 0.20 % to 0.10 % during storage. Magnesium content without insects remained almost the same, but in treatments with insects, it fell from 0.40 % to 0.20 %. During the first 120 days of storage P, K, Ca and Mg were highly variable, at 150 days of storage, the variability was less. The percentage of insect damage grain increased linearly with storage duration. The percentage of fungal damage grain increased during storage, and was highest in high-moisture maize. The species of fungus observed were *Aspergillus flavus*, *Fusarium* sp. e *Penicillium* sp.

Key words: Stored Grain Pests, Grain Quality, Storage grain.

Introduction

The process of loss of quality which grains are subject to and its magnitude results of the interaction between insects, fungi, acarus, the physical state of the stored product, and where and when occurs the intervention from the man in this process.

Weber (2001), approaches the production issue, where the availability in the necessary volumes and the generation of exportable surplus are fundamental elements in a country like Brazil, with its natural vocation to export food. However, quantity is not

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everything. More than ever, it is spoken nowadays about total quality, it is searched, it is demanded in all sectors and, in special, food quality must be observed.

For Lorini (2000), the growing need for products to supply the world demand of food, having in mind the population growth, demands that the quality of the grain harvested be kept, with minimum losses, till the final consume.

Lazzari (2002), says that the storage fungi are adapted to grow in materials with moisture levels in balance with relative humidity of 65-70 % to 85-90 %, which corresponds to moisture levels of 13-20% in maize, wheat, rice and 12-19 % in peanut, soy, sunflower and cotton.

For Lazzari (2002), the storage fungi are sensitive to temperature variations, growing faster at temperatures around 30 ºC. When the temperature is below 15 ºC, their development is greatly reduced with the exception of the *Penicillium* spp.

Materials and methods

An experiment was done at Pontifícia Universidade Católica do Paraná (PUCPR) aiming evaluate the variation of minerals concentration and total amount of protein considering influence of insect (complex *Sitophilus*, *(S. oryzae* and *S. zeamais)*) attacks and consequently fungal infestation in maize grains stored in great quantities during a period of 120 days.

An hybrid DEKALB-214 originally from Gralha Azul Experimental Farm, localized in a city called Fazenda Rio Grande, Paraná State, Brazil, was used without any pesticide treatment. The product was obtained manually from corncobs, kept clean in an environment with humidity rate at about 22 %. Forty kilos were dried in laboratory to get 13 % of moisture content, and forty kilos were kept at harvest moisture content (about 22 %).

Both maize samples with different humidity rates were divided in 4 portions as following: dried maize without insects (20 kg), dried maize with insects (20 kg), regular maize without insects (20 kgs), regular maize with insects (20 kgs), with four repetitions in 5 different times of evaluation (0, 30, 60, 90 e 120 days)

In the insect infected portions were released 20 adult individual of the complex *Sitophilus*, (*S. zeamais*), sexless and without defined age, originally from populations collected at Parana State, and kept in the Laboratório de Entomologia Aplicada do Depatarmento de Zoologia da Universidade Federal do Parana.

The samples were stored in plastic containers with metallic covers in order to allow the natural exchanges between the grains and the environment. The analyses were done at the Laboratório de Bioquímica da Pontifícia Universidade Católica do Paraná with 200 grains taken out of each portion. The evaluation considered: the number of grains attacked by insects, the percentage of grains attacked by fungal, the total percentage of nitrogen, potassium, calcium, magnesium and proteins according to analyses procedures of Kjeldahl.

A microbiological analyses was done at the Laboratório de Fitopatologia da Pontifícia Universidade Católica do Paraná aiming to identify fungal presence during the period of tests. The procedures used for identification were the same ones used for the Laboratorio de Fitopatologia da Pontifícia Universidade Católica do Paraná. The pathogens identification throw “gerbox” layers stimulated the development of microorganisms present on the grains, which were identified later.

Results and discussion

In Figure 1 it is possible to see the results obtained for % of nitrogen in the grain throughout the time due to the moisture level of the grains and presence or absence of insects. It can be verified that for the wet grains with insects and for the dry grains with and without insects there was the same tendency for the increase in the N in the grain throughout the time, reaching the maximum level around the 90 days, when then it showed a slight decrease till the 120th day. The average increase was 0.2 % of N in the grain, which represented an increase of 15.3 % in the level of N of the grain. For the wet grains without insects there was a more stable tendency in the % of N of the grain till the

60th day, when then an increase can be seen till the 120th day. The average increase observed was 0.05 % of N in the grain, which represented an increase of 3.4 % in the level of N of the grain. Considering that the curve obtained for dry grains without insects would be like a marker curve, it is seen that the alterations in the % of N of the grains were not provoked by the presence of insects.

In Figure 2 it is possible to see the results obtained for the protein level of the grains, where we can verify that, there was a tendency of a small increment in the protein level in the dry grains with and without insects and for wet grains with insects, showing an average increase of 1.26 % in the protein level of the grains, while with the wet grains and without insects, the tendency was close to linear, with a small increment of 0.3 % in the protein level of the grains throughout the 120 days. The average increase in the protein level of the grains, independent of the moisture or presence or absence of insects was 15 %.

It can be seen in Figure 3 that the percentage of phosphorus in the grains showed a decrease in relation to initial levels, and the decrease rate was higher up to the 90 days and, after this period there was a balancing in the percentage of phosphorus in the grains till the 150 days. The average decrease in the phosphorus level for all the treatments was 69.6 %.

In Figure 4 it is possible to see the results obtained for % of potassium in the grain throughout the time due to the moisture level of the grains and presence or absence of insects. It can be seen that for all treatments there was a decrease in the percentage of potassium throughout the period of 150 days, showing an average decrease of 56 % in relation to initial levels. According to the curve obtained for dry grains and without insects (marker), it can be seen that there was no influence from insects and from the moisture level of the grains in the decrease of the potassium levels, featuring only the effect of the storage period.

It can be seen in Figure 5 that, independently of the treatment, there was a general tendency of decrease in the percentage of calcium of the grains, showing a loss of 0.07 % of calcium in the grains throughout the period of 150 days, which represents a decrease of 43.7 %. The highest rates of decrease occurred in the first 80 days and, after this period, there was a balancing in the percentage of calcium

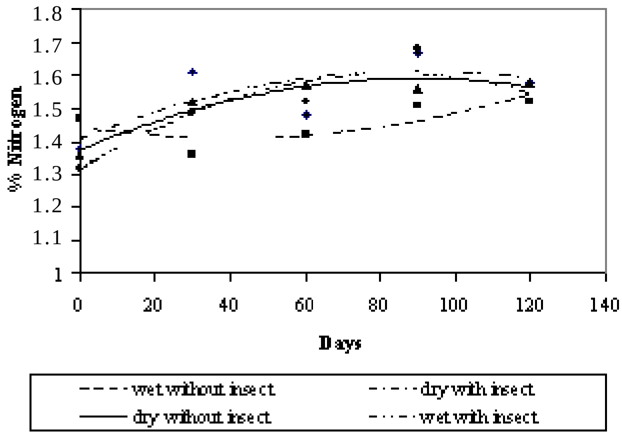

Figure 1. Nitrogen changes in maize stored during experimental period.

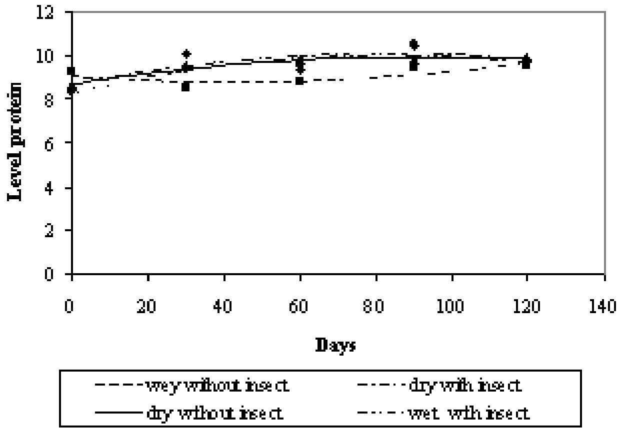

Figure 2. Protein level changes in maize stored during experimental period.

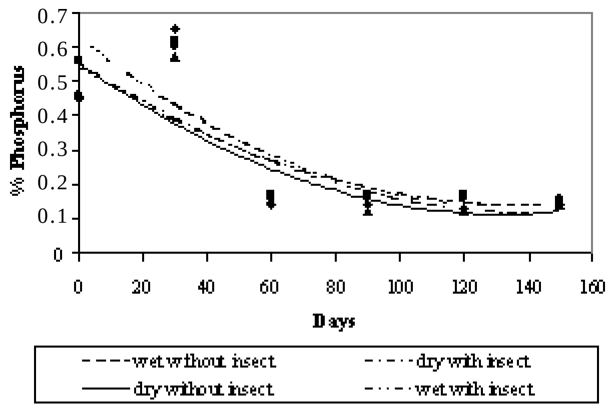

Figure 3. Phosphorous changes in maize stored during experimental period.

(0.09 %). It is evident then that the biggest effect in the decrease in the percentage of calcium in the grain was because of the storage period and not because of any effects from moisture or presence or absence of insects.

In Figure 6 it is possible to see the results obtained for % of magnesium in the grain throughout the time due to the moisture level of the grains and presence or absence of insects. It can be seen that, independently of the treatment, there was a decrease in the magnesium level throughout the period of 150 days in relation to the initial levels, in a way that, the smallest reductions (30 %) occurred with the wet grains without insects, while the biggest reductions happened with the dry grains with insects.

In Figure 7 it is possible to see the damages from the insects throughout the time. It can be seen that for both dry maize (13 %) and for wet maize (22 %) there was a linear increase in the percentage of damages in the grains throughout the 150 days due to the presence of the insects, without any significant difference between both treatments, in a way that an increase of 0,11 % of damage in the grain for each day of storage can be seen.

In Figure 8 it is possible to see the results of the percentage of damage in the grains caused by fungi. It can be seen that the smallest fungal damages were obtained in the dry grains with insects, showing an increase of 0.16 % per day, while the biggest increase of fungal damage in the grains were obtained in the wet grains without insects, with an increase of 0.36 % per day. From the results obtained, it can be seen that, the most important factor in the increase of damage by the fungi in the grains was

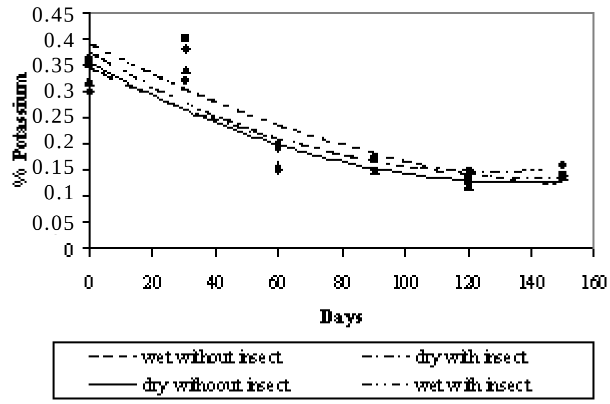

Figure 4. Potassium changes in maize stored during experimental period.

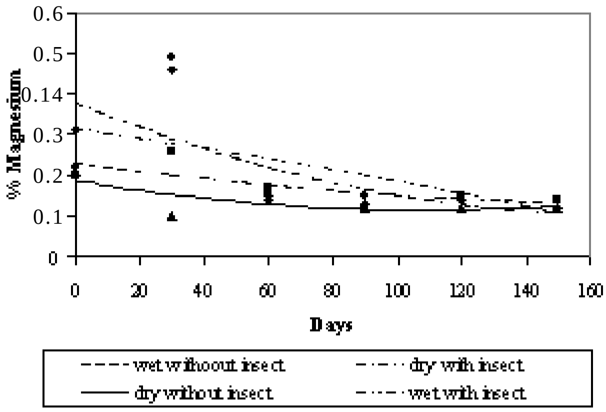

Figure 6. Magnesium changes in maize stored during experimental period.

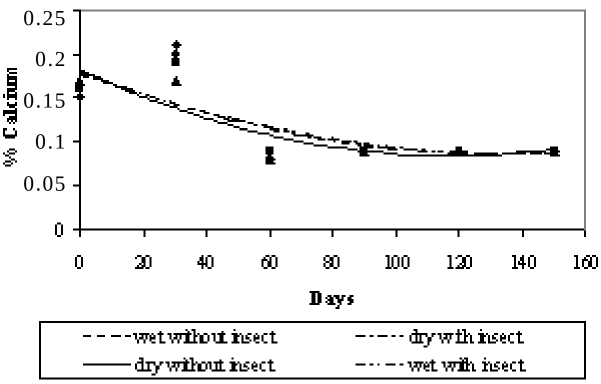

Figure 5. Calcium changes in maize stored during experimental period.

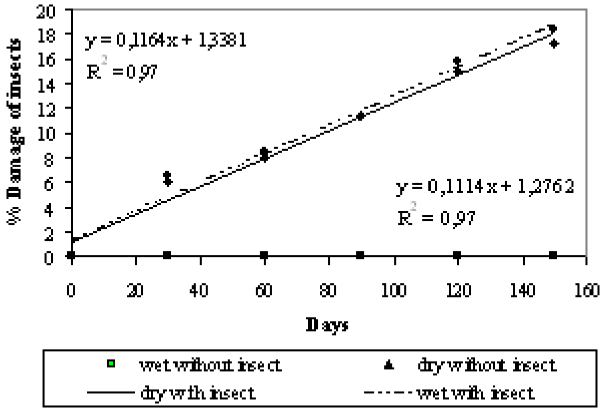

Figure 7. Damage of insects in maize stored during experimental period.

the moisture level.

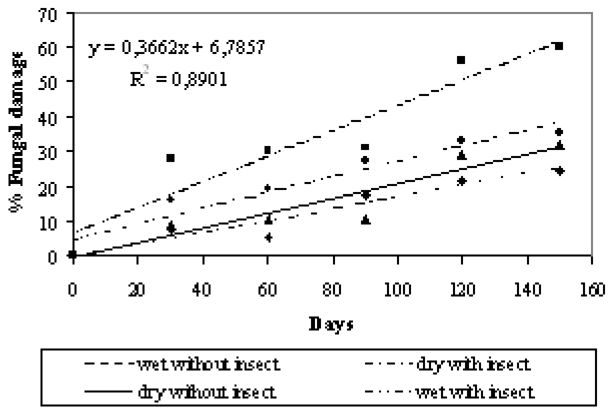

Figure 8. Fungal damage in maize stored during experimental period.

Rehman et al. (2002) observed nutritional changes in maize grains stored at 10, 25 and 45 °C for 6 months. Significant decrease in pH and increase in titratable acidity was observed during storage of maize grains at 25 and 45 °C. Moisture contents of maize grains decreased by 25 % at 25 °C and 38 % at 45 °C after six months of storage. Total soluble sugars increased by 10.7 % at 10 °C and 17.3 % at 25 °C, whereas a 39.5 % decrease was observed after 6 months storage at 45 °C. Total available lysine and thiamine contents in maize grains decreased by 13 and 9.26 % at 25 °C, 16 and 20.4 % at 45 °C, respectively, after 6 months of storage. Protein digestibility decreased by 5.19 and 9.0 % at 25 and 45 °C, respectively, whereas decrease in starch digestibility was 9.86 % at 25 °C and 15.1 % at 45 °C on storage of maize grains for 6 months. However, no significant nutritional changes occurred during storage of maize grains at 10 °C.

Based on the obtained results and on the conditions in which this experiment was carried out, we can conclude that: In relation to the variation on the N and Protein levels, it was observed that the values of protein in the treatments of dry maize with insects, dry without insects and wet with insects increased their concentration of Protein when taken in account the values in the beginning of the storage period, but this variation was not significant.

The Phosphorus values in the different treatments obtained a variation from 0.65 % to 0.15 % of the initial value.

The Potassium levels of the different treatments had a decrease from 0.40 % to 0.15 % approximately, when observed the values obtained in the analyses.

The Calcium values of the different kinds of treatment had a decrease of approximately 0.20 % to 0.10 % during the storage period.

The Magnesium values of the corn treatments without insects were kept practically the same, but the values of maize with insects had a decrease from 0.40 % to 0.20 % approximately.

The elements P, K, Ca, and Mg had their biggest variation up to 120 days after the storage, tending to reduce the amplitude after this period.

Taking in account the percentage of attack of insects, it is possible to conclude that the intensity increases as the storage period continues, independently of the treatments proposed.

The percentage of fungi attacks in all kinds of treatment when analyzed separately, the treatment with wet corn without insects had an increase in the percentage of fungi attack when compared to the other kinds of treatment, but it also emphasized that the treatment of wet corn with insects obtained a bigger percentage of attack, when compared to the treatment of dry maize. The percentage of fungal damage grain increased during storage, and was highest in high-moisture maize. The species of fungus observed were *Aspergillus flavus, Fusarium* sp. and *Penicillium* sp.

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