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Interaction between pest infestation and fungus in wheat grain at storage facilities

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Abstract

The interaction between pest infestation and fungus and mycotoxin contamination in wheat grain was studied during six months of storage from November 2003 to May 2004. The wheat grain was stored in a silo of 1,000 tons of capacity, virtually divided in five identical layers of grain with 30 days samples taken from the silo and analyzed as to the presence of insect pests, fungus and mycotoxins. The grain samples were sieved and the insect pests were identified and associated with the fungus contamination in the insect's body and in the grain by culturing the grain samples in laboratory. The results showed that during the 180 days of storage the mean numbers of insect pests varied between 1.0 and 7.0 insects per sample representing 85.7 % of samples with live insects. Also, the mean numbers of dead insects varied from 1.0 to 11.0 per sample. At one day of storage no live insects were found through sampling in the silo. The results also showed that an average of 1.71 larvae, 0.57 whole insects and 15.2 insect fragments per sample were found in the kernel of the grain throughout the storage period. As these species found in the grain have a short life cycle and are highly prolific they can cause a lot of damage in the bulk grain even with just a small population detected. Also these pests carried in their body fungus that can produce mycotoxins which cause risks to humans and animals that consume it and also they can damage the quality of the grain at industrial processes. Such results indicated the need of an intense inspection of the storage facilities to assure exemption of insect pests in the facilities.

Key words: storage wheat grain; pest infestation; kernel contamination.

Introduction

Inadequate product storage and handling can increase quality losses characterized by an increase in fungus and insect contamination susceptibility, decrease of the germination capacity, visible decay, loss of color, bad smell, loss of dry material, temperature increase and chemical and nutritional changes (Pomeranz, 1982; Lacey et al., 1991). Large quantities of moldy stored grain and difficulties in grain and flour commercialization, due to insect and insect fragments presence caused by bad storage, are frequently observed (Lorini, 2003). Hygiene

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problems can happen in raw material, during industrialization and even in the final product, which makes systematic food control necessary, as food can be contaminated by pests during transport, storage and processing (Mattos et al., 2003).

Insects are some of the factors that are directly related with cereal quality and quantity losses (Birck et al., 2003a; 2003b). The insects involved in the storage and industrial processes belong to the *Sitophilus oryzae, S. zeamais, Oryzaephilus surinamensis, Tribolium castaneum, Rhyzopertha dominica* and *Cryptolestes ferrugineus* species (Lorini, 2003). The grain weight losses, caused by warehouse pests, presence o insect fragments in grain byproducts, deterioration of the grain bulk and fungus and mycotoxin contamination cause negative effects to human and animal health and cause also product and byproducts export difficulties, due to the potential contamination risks; consisting in one of the problems that bad grain storage causes to the Brazilian society (Lorini, 2002; 2003).

The presence of adult and larvae insects as well as other non-grain material in the grain bulk indicates problems in the cereal's cleaning process. Whole insects, insect heads, whole larvae and larvae heads recovered by the intern infestation method indicate that the cereal contained primary larvae and insects inside the grain, and that the presence of eggs, pupae, larvae and adults in the samples show that there were insects with biological activities, completing their life cycle in this product (Atui et al., 1998). The greatest population growth was of the *R. dominica* in wheat, through different temperatures and humidity grades, at 33.3 ºC, decreasing to temperatures of less then 32 ºC (Silva et al., 2003). This same species had a reduction in the population growth with temperatures of 16 ºC, but was not extinct during the 90 days storage period. Insect presence in grain can also increase the temperature due to the pests' metabolism (Christensen and Kaufmann, 1974).

The food pastas, or macaroni, that have as its main raw material the wheat flour can show biological contamination, due to insect fragments in the stored wheat grain (Zamboni and Atui, 1989).

The aim of this study was to assess insect infestation on wheat grain, insect fragments in wheat flour and it's relation with fungus and mycotoxins during storage.

Material and methods

The experiment was performed at Cotriguaçu Mills, located in Palotina, in the state of Paraná, during six months of storage from November 2003 to May 2004. After harvested the wheat grains was cleaned and dried as recommended by the Brazilian standards. The grain was stored in a silo of 1,000 tons of capacity, virtually divided in five identical layers of grain with 30 day samples taken from the silo and analyzed for presence of insect pests, fungus and mycotoxins. The grain samples were sieved and the insect pests identified (AOAC, 2000) and associated with the fungus contamination in the insect body and in the grain by culturing the grain samples in the laboratory. Also the mycotoxin contamination was investigated in each sample following the AOAC methodology (AOAC, 2000). The 1,000 tons used in the experiment were stored in a vertical concrete silo of 18.0 m of height and 14.8 m of diameter and was virtually divided in 5 equal parts (A, B, C, D and E), 5 samples were collected per period (1, 30, 60, 90, 120, 150 and 180 days), in a total of 35 samples collected during the experiment.

The silo was divided in the subsequent manner: point A from 0 to 3.6 m of the base, point B from 3.6 to 7.2 m of the base, point C from 7.2 to 10.8 m, point D from 10.8 to 14.4 m and point E from 14.4 to 18.0 m of the base. The 20 kg of raw samples homogenized by manual quartering techniques until 1 kg was obtained, which was later grinded, homogenized and subdivided so as to determine the presence of insects in the grain bulk and inoculated in a laboratory culture.

Results and discussion

The insects found in the stored wheat grain belonged to the *Rhyzopertha dominica, Sitophilus zeamais, Cryptolestes ferrugineus* and *Liposcelis* sp species. The intern and extern adult insects' infestation dynamic varied during the 180 days of storage, and can be detailed as follows:

a) In the samples collected at 1 day of storage, no adult insect was detected in the grain but six insect fragments were found in the five samples.

b) After 30 days of storage, 15 live adult insects from the *R. dominica, S. zeamais* and *C. ferrugineus* species were found. Another seven live insects from the *Liposcelis* spp. species and three dead insect of the *C. ferrugineus* species were detected in the samples. In the intern grain infestation analyses, a total of 22 larvae, 11 whole insects and 76 insect fragments were found in the sum of the five samples.

c) After 60 days of storage, the *C. ferrugineus*, one live adult insect, and S. *zeamais*, two dead specimens, species were detected. In the intern grain infestation analyses, a total of 6 larvae and 16 insect fragments were found in the sum of the five samples.

d) At 90 days of storage only three live adult insects of the *C. ferrugineus* species were found. The intern grain infestation analyses detected the presence of three whole insects and two insect fragments.

e) At 120 days of storage just um dead insect of the *S. zeamais* and three live and one dead insects of the *C. ferrugineus* species were found. On intern grain infestation analyses, one larvae, 4 whole insects and 8 insect fragments were found.

f) At 150 days of storage, the *C. ferrugineus* and *Liposcelis* spp. species were found, with seven live and 13 dead insects of the first species and one live insect of the second. The intern grain infestation analyses showed 6 larvae and 10 insect fragments.

g) After 180 days of storage only um live insect of the *C. ferrugineus* species was found. The intern grain infestation analyses detected only 6 insect fragments.

The mean general intern infestation, during the 180 days, was of 1.71 larvae, 0.57 whole insects and 15.2 insect fragments per sample. As the Brazilian legislation (Brasil, 2003) doesn't establish tolerable limits for whole insects in the flour, these values agree with the Brazilian market.

According to Lorini (2003), the *R. dominica* and *S. zeamais* pests are intern primary pests that perforate the grain and then penetrate them so as to complete their development, feeding on the grain's interior and enabling the installation of other grain deteriorating agents. The *C. ferrugineus* and *Liposcelis* spp. species are classified as secondary pests, as they can't attack whole grain and only feed on damaged or broken grain. The *Liposcelis* spp. species is mainly attracted by flour and dust.

The results found in this study confirm those described by Lorini (2003), as of the 35 analyzed samples, 5.7 % showed presence of live insects from the *R. dominica, S. zeamais* and *Liposcelis* spp. species and 45.7 % from the *C. ferrugineus* species.

The laboratory analyses done with the adult insects found during the experiment, showed presence of warehouse fungus that produce mycotoxins, which are harmful to humans and animals. In this manner, we can establish the wheat grain and byproducts contamination relations by fungus carried in the body of stored wheat pests, the insects being considered mechanical vectors.

Mattos et al., (2003) while assessing various food groups conclude that, among the non-grain material, the most common were whole insects, larvae, amorphous material, insect fragments and carbonized particles. Atui et al. (1998) made a study during four months on maize grain samples before and after processing, using the AOAC method and the Microscopic Food Analyses Manual (Zamboni and Atui, 1989). Of the 81 maize grain samples analyzed by the sieving method, 29.6 % showed live insects, 28.4 % dead insects and 72.8 % metal particles. By the intern investigation method, 79.0 % of the samples showed whole larvae, 43.2 % larvae heads,

37.05 % insect heads and 27.2 % whole insects. According to Atui et al., (1998), the sieving method is the most adequate method for detection of live infestation, metal particles and insect parts; this was confirmed by the current study.

High percentages of samples that contain insect fragments indicate that the grain used is internally infested (Atui et al., 1998). The acid hydrolysis method is faster, has a lower cost and allows a better counting of insect fragments and rodent hair (Zamboni and Atui, 1989).

Birck et al. (2003a) while studying the quality of common and special flour during the milling process after the implementation of the Integrated Pest Management of Stored Grain (MIPGRÃOS) program, concluded that there was a reduction in the number of fragments during monitoring and that this measure, as well as others related, need a strict control so as to be efficient. During the implementation of the MIPGRÃOS program at Cotriguaçu Mills, the presence of insect fragments in the flours produced was monitored. The results showed that the mean of insect fragments in common flour in the year of 1999 was of 32 fragments; in 2000, 19 fragments; in 2001, 17 fragments; and in 2002 it was of 22 insect fragments. For special flour, the mean of the year of 1999 was 42 insect fragments; in 2000, 13 fragments; in 2001, 17 fragments and in 2002, 13 insect fragments. It was concluded that the results of the implementation of the MIPGRÃOS program was positive, indicating excellent sanitary conditions in the flour industrialization process in the mill.

The insects carry fungus spores, as well as other contaminants, that while attacking the grain can cause a raise in the product's humidity grade great enough to enable the development of fungus that are in a latency process. It is important to point out that we must not consider the insect problem isolate issue but as in a strict relation with microorganisms.

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