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Traceability in the wheat production chain

F.C. Ceruti[1,*], S.M.N. Lazzari[1], F.A. Lazzari[1]

Abstract

To whom does it interest the identity preservation and traceability of grains? Obviously to the processing industry and to the final consumer. It interests to the industry because it will process better quality grain with low contamination and at reduced costs. It also interests to the consumer because he will be taking safer and better quality food. Despite the difficulties of implementing identity preservation and traceability programs of grains in Brazil, there are some systems working satisfactorily for meat production, seeds and fruits. In the grain production chain this is the correct right way, technology is available; however, many problems need to be overcome from the field to storage and processing to succeed with quality preservation. There are limitations on storage infrastructures (grain pits and dryers), equipment for measuring quality, trained personnel and silos for segregation. A decision support system was developed with the objective of recording the procedures for wheat production from the field to the consumer. All the important steps for quality maintenance of stored wheat were evaluated for one year. Monitoring of insect pests and control measures, including application of diatomaceous earth and artificial grain cooling, was carried out during the storage phase. The treatments were evaluated by measuring the presence of insect fragments and determination of the wheat flour quality. Based on a detailed documentation of the procedures, a database was generated to recover information from the process. The decision support system created was a very simple tool, but valuable for traceability of grain quality, which added value to the grain and increased food safety.

Key words: food safety, grain quality, preserved identity, stored product insects, traceability.

Introduction

Wheat is a major food and important commodity in the world grain market. It has been cultivated since early civilizations. People have learned to select seeds to improve production and flour processing. According to the United States Department of Agriculture (USDA, 2006), the world wheat production in 2005/06 surpassed the 620 million metric tons and the world consumption was about 608 million tons. The major world wheat producers are: China, India, USA, Russia, European Union, Canada, and Australia. In South America, Argentina is the major producer. USA and Canada export mainly to China, India, Russia, Japan, and Brazil. The wheat production in Brazil does not cover the internal consumption, where the states of Rio Grande do Sul and Paraná stand out as the largest national producers. About 75 % (approximately 6.3 million tons) are milled into flour for breads, pastries, crackers, and noodles, and the remaining

[1] Departmento de Zoology, Universidade Federal do Paraná, Caixa Postal 19020, 81531-980 Curitiba, Paraná, Brazil

* Corresponding author. Tel.: +55 41 3361 1785; fax: +55 41 3361-1763. E-mail address: biaceruti@yahoo.com.br (F.C. Ceruti).

25 % are left for mill feeds.

For each specific end use, specific varieties and classes of wheat should be produced, received, and stored separately, then go through the milling process accordingly. The flow through the elevator follows the steps: weighing, sampling, and analyzing (foreign materials, insects, damaged kernels, moisture, protein content, and α -amylase activity). Then the wheat goes through a receiving separator before storage, segregating the lots according to class, grade, and protein content. The grain mass is usually fumigated, treated with liquid insecticide, or aerated to avoid or reduce insect infestation. (Bass, 1988)

In order to provide the milling industry with specific wheat varieties for specific products, it is necessary to follow a rigorous traceability or rastreability program during the process. Traceability is a mechanism that allows identifying the origin of the product from the field to the consumer; it consists of a series of steps and measures that makes it possible to control and to monitor all the procedures along a process (Pallet et al., 2003). Another important factor that makes the traceability essential is that nowadays, the consumer is deeply concerned with food safety, and the quality should be guaranteed for internal and international marketing (Mariuzzo and Lobo, 2003).

Recording all activities during the process makes it easier to detect and solve problems that may occur (Pallet et al., 2003). For Costa and Euclides Filho (2002), traceability promotes the transparency warranty for the consumer about the quality and the content of a given product as indicated on the package.

Brazil has already implemented rastreability systems for meats, fruits and genetically modified soybeans and more recently for processed milk (Machado, 2005). Despite the importance of segregating special grains and seeds, there are still many constraints for preserving the identity and tracing grain loads for specific purposes. The limitations are mainly the inadequate storage infrastructure and shortage of trained personal.

To protect grain quality during storage, several procedures and measures need to be observed, such as insect and other pests monitoring and application of control measures (Fleurat-Lessard, 2002). The control includes chemical methods and physical methods, such as aeration, artificial chilling, and diatomaceous earth application. Grain should be pre-cleaned and the storage facilities and machinery should be cleaned frequently to insure the effectiveness of any control measure.

Insect pest monitoring is a basic IPM tool to evaluate infestation levels. It determines the species present, the potential for the species causing economic damage, and the control decision needed (Longstaff, 1997). The control measures adopted in IPM programs should preserve the quality of the grain without causing other problems, such as insecticide residues in the products, chemical exposure of the operators, environmental contamination, and pest resistance. They should also have a satisfactory cost-benefit ratio.

For identity preservation and traceability along the grain chain, a detailed step by step documentation of the whole process is needed. It can be accomplished by a database program or expert system (Flinn et al., 2002).

The objectives of this research was to: 1. study the postharvest stage of the wheat production chain; 2. monitor insect infestation with different traps; 3. evaluate different insect control measures; 4. develop a decision suport system as a tool to record all the data needed for identity preservation, and to trace the grain flow back and forth to improve processes and quality maintenance.

Materials and methods

The experiment was carried out in a grain facility in Paraná State, southern Brazil. The postharvest flows of three wheat loads were monitored from receiving through storage (during 12 months) and milling. The grain lots were analyzed and graded, dried and stored in three separate 1,100-ton metallic silos. A different insect control method was applied in each silo:

1) Silo 5/Lot 1 – liquid insecticides applied on the grain in the conveyor belt (Actellic®, 18 ml/ton plus K-Obiol®, 13 ml/ton), 2) Silo 14/Lot 2 – diatomaceous earth (Keepdry®, enveloping the grain mass 30 kg/silo) and artificial chilling using a machine developed by Cool Seed (PC040, aerating at 10 °C for 120 hours), and 3) Silo 15/ Lot 3 - diatomaceous earth mixed with the grains on the conveyor belt (800 g/ton) plus artificial chilling as above.

The treatments were evaluated every 15 days by monitoring the insects by using probe traps inside the silo (15 traps/silo - three in the center and three in each cardinal point); 14 cage traps on the flour outside the silos (two nearby each silo and the others by the grain pit, cleaning area, and between the other silos); and delta traps with and without moth pheromones, two of it in each silo, placed 1 m above the grain mass inside the silo (Figure 1).

The software System of Traceability was designed with each particular grain load called an entity. Every entity has its origin recorded. The stages of the wheat production chain are called phases; and during each phase several procedures may be adopted and recorded to allow the traceability of each entity. The system administrator can create all the fields and the screens that should compose the traceability of the product/entity. After composing the screens (origin, entity, phases, processes) the system is ready to be completed by the user with the data he or she considers appropriate to follow up the process. The information can be recovered and reports can be printed by the user. In order to implement these functionalities into the on-line system, the language PHP 5 was used in an Apache Web v. 1.3.33 server (Apache Software Foundation, Europe). The data storage was in XML file format, which are manipulated using DOM and SAX parsers.

Results

A series of processes was carried out and recorded during the receiving, drying, and storage phases. The results of the treatments were evaluated based on insect capture data, which were recorded into the appropriate fields of the software. This database system tool offers flexibility to allow the administrator and/or user to

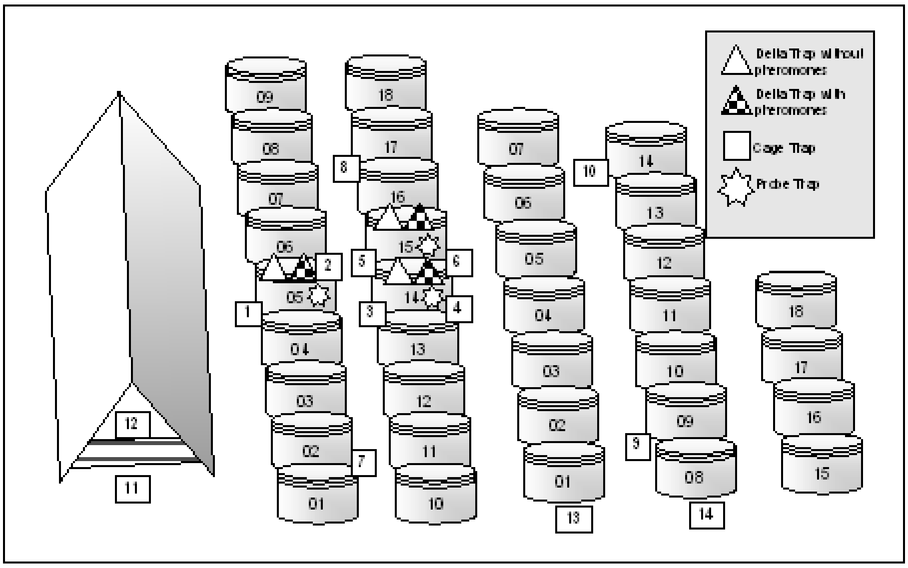

Figure 1. Distribution of the traps used for insect monitoring in a grain storage facility in Paraná State, Brazil. Silo 5 wheat CD105; Silo 14 and 15 mixed wheat classes.

define all the fields that appear in the screens (Figure 2). The user enters his login and a password to access the system.

The CD105 and the two mixed wheat lots were graded as follows: maximum 13 % grain moisture (wet basis), above 78 PH-value, 1.5 % of foreign materials, and 1 % of damaged kernels (burned and insect damage). Figure 3 presents the data for Lot 1, as an example of the data entry in the program. After 12 months of storage, the wheat kernel moisture content of load 1 was 12.4 %, load 2 was 12.6 %, and load 3 was 12.5 %.

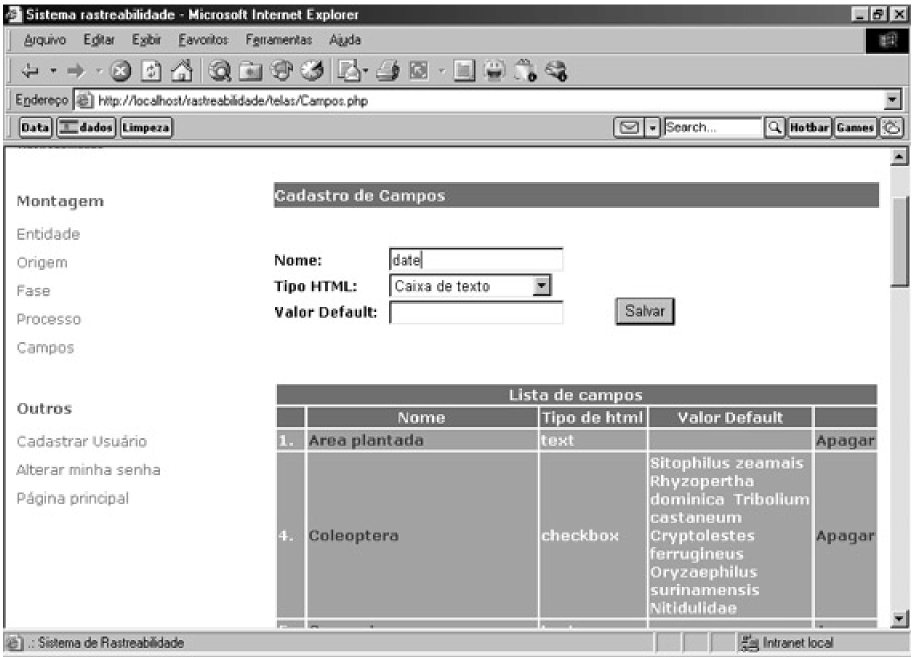

Figure 2. Screen of the Traceability Software showing the fields records of a lot of wheat.

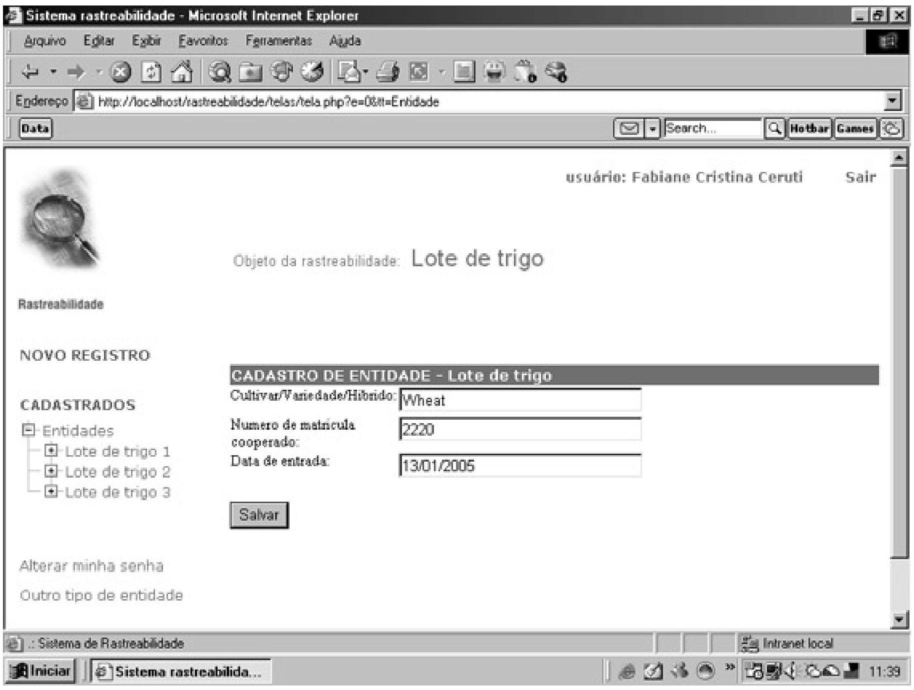

Figure 3. Screen of the Traceability Software showing the data about the origin of a lot of wheat.

The data on the total insect capture is presented on Table 1. It can be observed that grain infestation was very low, represented mainly by Gnatocerus cornutus (Fabricius) and *Tribolium castaneu*m (Herbst), consideradas pragas secundárias de grãos armazenados captured in the probe traps. However, the cage traps captured a greater number of coleopterans and psocids outside the silos. The moths, also at low numbers were captured only in the pheromone traps.

All these data of insect monitoring were entered into the program. A link with diagnosis and pictures of stored product insects may be accessed if the user has any doubts about identification (Figure 4).

Based on the number of insects captured in the probe traps, it was observed that there were no significant differences between treatments (Figure 5). All the information about the treatments were recorded in the system, as displayed on Figure 6.

After one year of storage, the three loads of wheat were milled. The grain was analyzed right before and after milling, and no significant difference was observed between the three treatments for falling number, tenacity, extensibility, strength, and moisture content).

Concerning insect infestation, silo 5 treated with chemical insecticides was highly infested with insects, especially in the last month of storage. In this load, 5 insect fragments were detected in 50 g of flour. In the samples of the other two loads, none insect fragment was detected.

Table 1. Number of insects captured with traps in the grain mass (probe traps) of wheat and in traps out of the silos (delta and cage traps), from January 2005 to January 2006, in a grain facility in Paraná State.

Insect Order/Family/spp.	Probe trap	Delta trap	Cage trap	Total
Coleoptera				
Bostrichidae				
Rhyzopertha dominica (Fabricius, 1792)	0	0	17	17
Curculionidae				
Sitophilus zeamais Motschulsky, 1855	0	13	3,313	3,326
Nitidulidae				
Carpophilus spp.	0	0	40	40
Tenebrionidae				
Gnatocerus cornutus (Fabricius, 1798)	144	0	444	588
Tribolium castaneum (Herbst, 1797)	111	0	181	292
epidoptera				
Gelechiidae				
Sitotroga cerealella (Olivier, 1819)	0	4	0	4
Pyralidae				
Cadra cautella (Walker, 1863)	0	11	0	11
Plodia interpunctella (Hübner, 1813)	0	24	0	24
Psocoptera				
Liposcelidae				
Liposcelis spp.	3,293	262	160	7,715

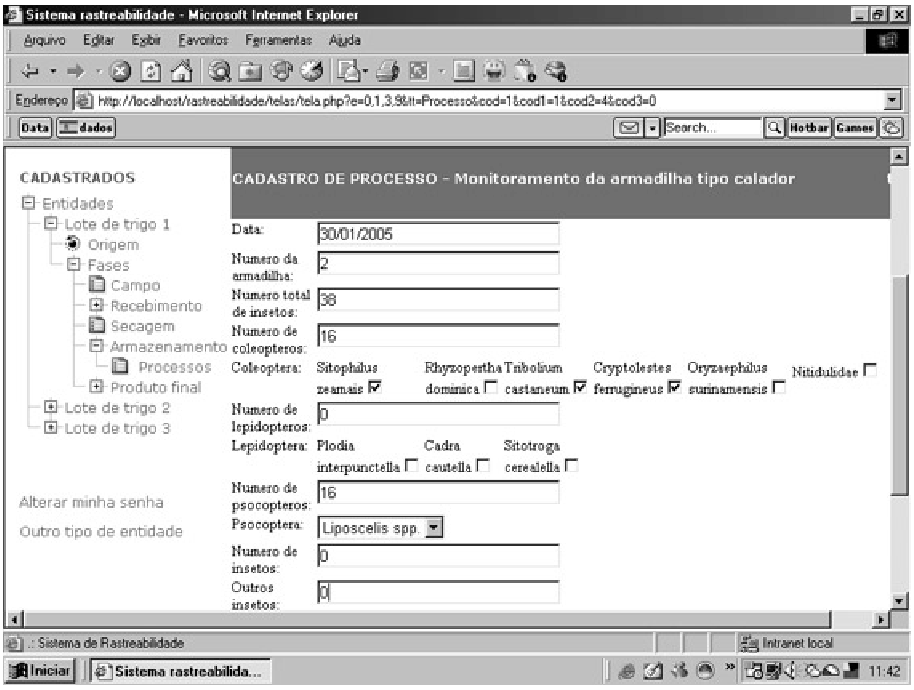

Figure 4. Screen of the Traceability Software showing the data about the insect monitoring with probe traps in a silo with wheat, January 2005 to January 2006 - Paraná, Brazil.

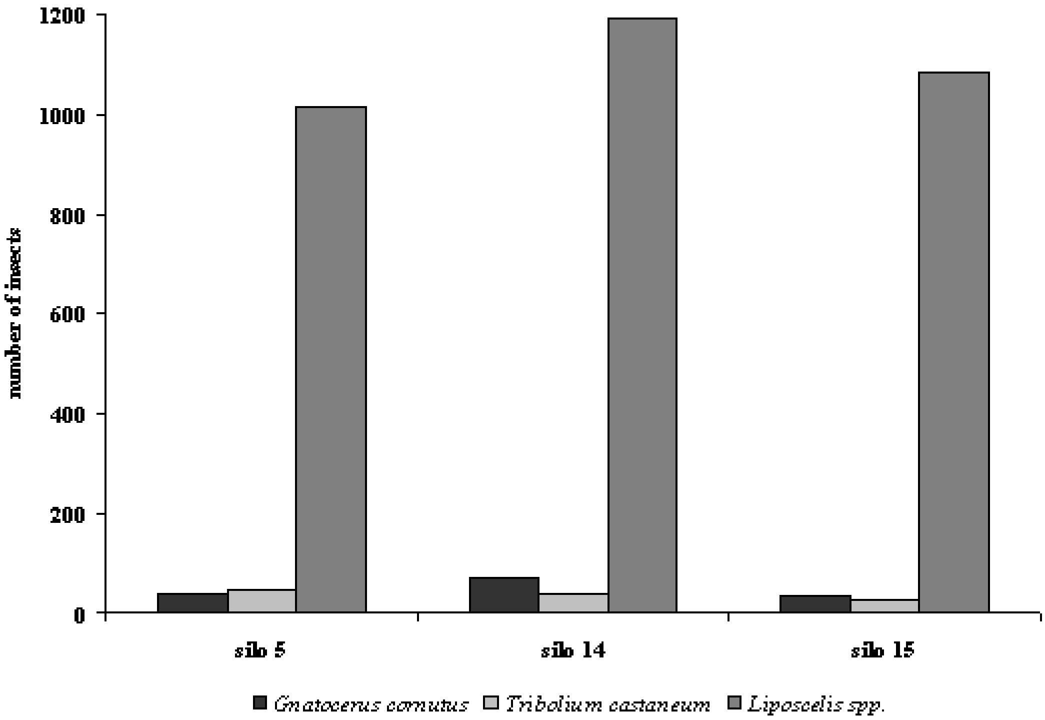

Figure 5. Total number of insects captured with probe traps in silos with stored wheat: Silo 5/Lot 1 –Actellic®, 18 ml/ton plus K-Obiol®, 13 ml/ton; Silo 14/Lot 2 – Diatomaceous earth (enveloping the grain mass 30 kg/silo) + artificial chilling (air at 10°C for 120 hours); and Silo 15/Lot 3 - Diatomaceous earth mixed with the grains (800 g/ton) + artificial chilling. January 2005 to January 2006 - Paraná, Brazil.

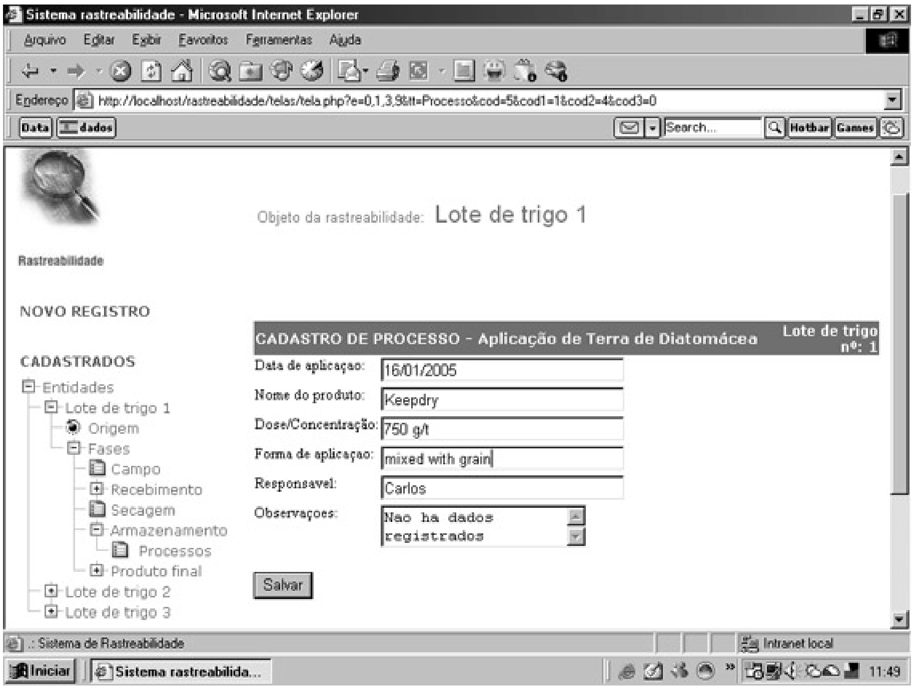

Figure 6. Screen of the Traceability Software showing the data about the insect control in a silo with wheat grains, January 2005 to January 2006 - Paraná, Brazil.

Discussion

According to a new resolution of the Brazilian Ministry of Health RDC N° 175, of July 8, 2003, the presence of vector insects (Diptera and Blattodea) is prohibited in food products, such as flours, but stored grain insect pests are not considered vectors. At present, the industry determines how many insect fragments can be tolerated in flour samples. The cooperative where the experiments were carried out tolerated 5 insect fragments per 50 g of flour.

The results of trapping allow the evaluation of occurrence and fluctuation of insect population in the grain mass and in the storage facility. They were also used to evaluate the efficacy of treatments and for control decision making. The greatest infestation detected in the wheat treated with chemical insecticide after 12 months of application was due to the short residual time of the insecticides. On the other hand, DE protected the grain against insect infestation for 12 months.

The flour beetles *G. cornutus* and *T castaneum*, commonly found in wheat flour, were the most common insect pests collected in the grain mass. The maize weevil was the most common coleopteran species captured in the cage traps around the silos, agreeing with Pereira et al. (2000), who captured 11 insect species in cage traps in a storage facility in southern Brazil, and *S. zeamais* represented 63.4 % of them. The associate psocids usually infest flour and may indicate increasing grain moisture because they feed on fungi and insect eggs (Dobie et al., 1984).

In order to maintain the total quality of wheat, all phases should be observed very carefully to avoid rejection of the lot or poor quality end products or even loss of reputation when the consumer is not satisfied with the product. In this context, the program of traceability may point out a problem in a specific area or procedure along the production chain. Thus, the problem may be corrected to avoid or reduce negative economic impact. The decision support system created for recording the data is a very useful tool for grain segregation and for traceability purposes. It is a very flexible program system and will be improved gradually according to the costumer's feedback.

Conclusion

The documentation of each step of wheat chain production allows the traceability of a grain load to maintain the quality for final processing;

Insect monitoring using multiple techniques is a valuable tool to detect insect infestation inside and outside the silos. Probe traps are useful to evaluate the efficiency of control methods.

Diatomaceous earth protects the grain mass against insect infestation for longer period than that of liquid insecticide applied during silo filling.

The software created for data recording is a simple, but useful decision support tool for the traceability process which purpose is to maintain quality of wheat from the field to the consumer.

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