Contribution of the light filth method to the Integrated Pest Management of a flour mill

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Abstract

An important contribution to Integrated Pest Management in stored-product protection can be provided by the light-filth method since it gives particular attention to the extraneous particles contaminating food (such as insects, insect fragments, mites, hairs, feather barbules, etc.), extending to the identification of the material from which they have originated or the animals and vegetables from which they derive or have been part of in the past. In this regard, semolina produced by an industrial mill (processing 500 t of durum wheat per day) located in South Italy was examined for light filth according to the method established by Italian regulation. During the investigations we verified the presence of insect fragments in 250 semolina samples collected from June 2008 to July 2009. Our results show that the number of insect fragments found in the samples (from 0 to 15 fragments per 50 g semolina) remained below the limit of 75 fragments per 50 g flour established by the Italian regulation. The fragments of arthropods found in the semolina samples had different origins. Numerous fragments came from both immature and adult insects infesting plants of wheat in fields (thrips and aphids); many other fragments belong to internal feeding insects and external feeding insects (*Sitophilus* spp., *Rhyzopertha dominica*, *Tribolium* spp., *Cryptolestes* spp., *Oryzaephilus* spp., and *Nemapogon granellus*) which are able to infest cereals during post-harvest processing or to colonize mill-rooms in which dusts, cereal debris, and flour residues are present. We also found fragments associable to structural pests like flies and psocids that are present in environments contaminated by mould spores and fungal hyphae. The results revealed that the fumigation of the mill realized in August 2008 did not modify the number of fragments contaminating the semolina, which remained at the same level during the 14 months of the experiment.

Keywords: Light filth, Semolina, IPM, Flour mill, Italy.

1. Introduction

In the last years, the European food industry has faced the need to give convincing answers to requests for qualitative standards of excellence in alimentary products with respect to both nutritional characteristics and hygienic-sanitary aspects. Therefore, the requirement for exclusion of arthropods from food has become a general exigency due to not only the comprehensible sense of repugnance generated by their presence but also the related health risks for people who ingest them. In fact, if any of the operators involved in the production chain starting from the fields up to the development are careless, insects and mites can proliferate, proceed to infest products ready to be packaged, and end up directly in the shops. There, if neglected, they can invade other wrappings and food and find their way inside the final consumers' houses.

To mitigate such problems, several active ingredients have been developed which are able to eliminate a large part of the pests for alimentary products, both in fields and in the subsequent phases of storage and food processing. As is known, this has involved abundant employment of insecticides, with the consequent development of pest resistance to various chemicals and furthermore serious environmental damage and risks for the health of the consumers.

With the aim of reducing the use of such substances, the concept of Integrated Pest Management (IPM) has recently found space in the food industry and spread in agriculture. IPM works as a multidisciplinary approach and introduces the concept of integration of the different methodologies to control infestations. In this way the tendency is to obtain long lasting results and certain advantages for the environment and final products. This multidisciplinary approach consists of: i/ *cognitive interventions*, through monitoring, identification of the infesting pests, and verification of the obtained results; ii/ *preventive interventions*, with the purpose of eliminating the favourable conditions for the development of the infesting pests; iii/ *corrective interventions*, through methods of direct attack and strengthening of preventive interventions (Trematerra and Gentile, 2008).

In such a context, an important contribution to the integrated management of the infestations can be provided by the light-filth method, as *cognitive intervention* in the IPM, since it pays particular attention to the extraneous particles contaminating food, extending to the identification of the material by which they have been originated or the animals and vegetables from which they derive or they have been part of in the past (Italian G.U., 1999). Much information to this matter can be found in Brader et al., 2002; Perez-Mendoza et al., 2005; Atui et al., 2006; Stejskal and Hubert, 2006; Neethirajan et al., 2007; Toews et al., 2007; Hubert et al., 2009; Trematerra and Catalano, 2009.

The main purpose of the present work was to evaluate the hygienic-sanitary quality of the semolina flour obtained by an industrial mill during one year, through isolation and identification of the extraneous particles contained in it, with particular attention to the fragments of insects.

2. Materials and methods

The observations were carried out in an industrial semolina-mill located in the Apulia region, South Italy. The mill was a large building of 18000 m^3, with seven floors processing 500 t of durum wheat, *Triticum durum* Desfontaines each day. The sampling was done for 14 consecutive months, from June 2008 to July 2009, focusing on four storage silos in the structure (identified by the numbers 23, 24, 27, and 28). Semolina to be analysed was collected with weekly frequency or, in any case, each time when one of the four monitored silos was filled with new semolina. In August, because of a fumigation treatment which involved the structure during the second week of the month, the operation of the plant stopped for about 10 d.

The analysed semolina was obtained from national and international (coming from different continents) grinding wheats, taken individually or as a mixture. Solid impurities were isolated, identified and analysed using the official light-filth method as given in the Regulation of the Italian Policy Agricultural Office, 12 January 1999, "Official Methods of Cereals Analysis – Supplement No. 5 'Determination of solid impurities in flour and transformed products' and 'Identification of substances of biological origin and mineral extraneous substances in cereal flours'".

For each sample, a quantity of semolina varying from 1.5 to 2.5 kg was collected from which a portion weighing at least 600 g was obtained using the standard sample division method in force, and homogenized inside their containers using a spatula. From these samples, 50 g of semolina was collected at different points, weighed for analysis, and introduced into a flask through a glass funnel used for dust handling.

Following the official methodology, the sample analysed was submitted to acetic-nitric digestion until ebullition, the impurities separated by flotation inside specific proportions of alcohol and gasoline in a Wildman trap flask, before being collected on a paper filter through deep-bed filtration with a Buchner funnel. The material gathered on the filter was observed through the microscope using lower magnification. In many cases, impurities were pulled out and placed on a slide in Faure's inclusion liquid and observed by the compound microscope for identification. According to the regulation, isolated and identified fragments were classified into different categories: whole insect (adult and/or larva); cephalic capsule of insects; fragment of arthropods; moth scale; hair of mammals (rodents, man, other); textile fibres; other fragments (metal, plastics, glass, combustibles).

3. Results

According to the results obtained during our analyses, fragments of insects identified through the light-filth method had different origins. Numerous fragments come from both immature and adult insects infesting wheat from the field. They belonged to phytophagous insects active on plants or on the ears of wheat (adult body or leg of aphids; and head, leg, and distal abdominal portions of immature and adult Thysanoptera). Many other fragments belong to specimens infesting post-harvest cereals (mainly head, mandible, and cuticular fragments of larvae; elytra and leg of adults; also whole larvae or adults). There were also internal-feeding insects (mainly *Sitophilus* spp. (Coleoptera: Curculionidae) and *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae), which are active on grains during storage but in some circumstances are able to begin their infestation in the field.

Represented in smaller quantities were external-feeding insects (for example: fragments of cuticle, leg, mandible, and also adults and larvae of coleopteran *Tribolium* spp. (Tenebrionidae), *Cryptolestes* spp. (Laemophloeidae), *Oryzaephilus* spp. (Silvanidae), and a lepidopteran *Nemapogon granella* (L.) (Gelechiidae), which are able to colonize stored cereals, mainly the machineries of mills in which dusts, cereal debris, and flour residues accumulate. Finally, among the observed semolina samples there were also fragments associable to environmental pests like flies (Diptera) and structural pests such as psocids (Psocoptera) that can proliferate in humid environments that facilitate fungus mycelium growth.

During our investigations, a total of 250 semolina samples were examined using the light-filth method (Figure 1). Different categories of solid impurities were found: i/ many of synthetic origin; ii/ some impurities of vegetable origin, related to the raw material, and iii/ some insect fragments. In this last category we found 599 fragments belonging to insects of different families. More specifically: i/ 152 insect fragments from 63 samples from semolina silo No. 23; ii/ 154 insect fragments from 63 samples from semolina silo No. 24; iii/ 157 fragments from 63 samples from silo No. 27; iv/ 136 insect fragments from 61 samples analysed from silo No. 28 (Table 1). Various semolina samples occasionally contained natural textile fibres, crystalline particles, and burned particles, but rodent hair was never found.

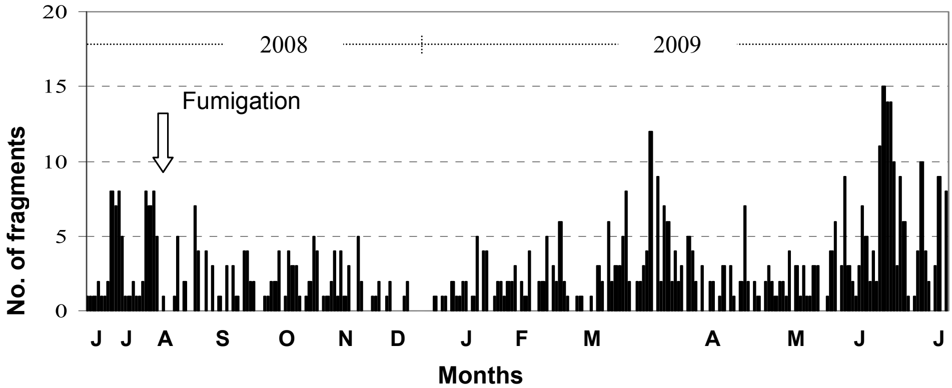

Figure 1 Total number of insect fragments recovered in semolina samples during 2008 and 2009.

Table 1 Insect fragments recovered in semolina samples.

Insect fragments	Silo 23	Silo 24	Silo 27	Silo 28	Total
Abdomen	8	9	5	5	27
Adult cuticular fragments	28	19	24	15	86
Antennas	0	4	6	9	19
Cephalic capsulae	6	6	2	3	17
Larvae cuticular fragments	8	7	8	6	29
Legs	25	30	30	32	117
Mandibles	42	50	51	43	186
Pronotum	4	2	2	1	9
Rostrum	1	1	0	1	3
Sternum	2	0	0	1	3
Torax	2	1	3	1	7
Moth scales	2	1	2	2	7
Unidentified fragments	9	6	7	5	27
Whole adults	5	4	5	3	17
Whole larvae	10	14	12	9	45
Total	152	154	157	136	599

Figure 2 shows the number of insect fragments found in each semolina sample, separated for each silo considered. Insect fragments were found in 142 samples (56.8% of cases) of the inspected semolina. Altogether, the number of insect fragments found in the 250 samples ranged from 0 to 15 fragments per 50 g semolina. This was below the average defect action level of 75 fragments per 50 g flour established by the Italian regulation (Italian G.U., 1999).

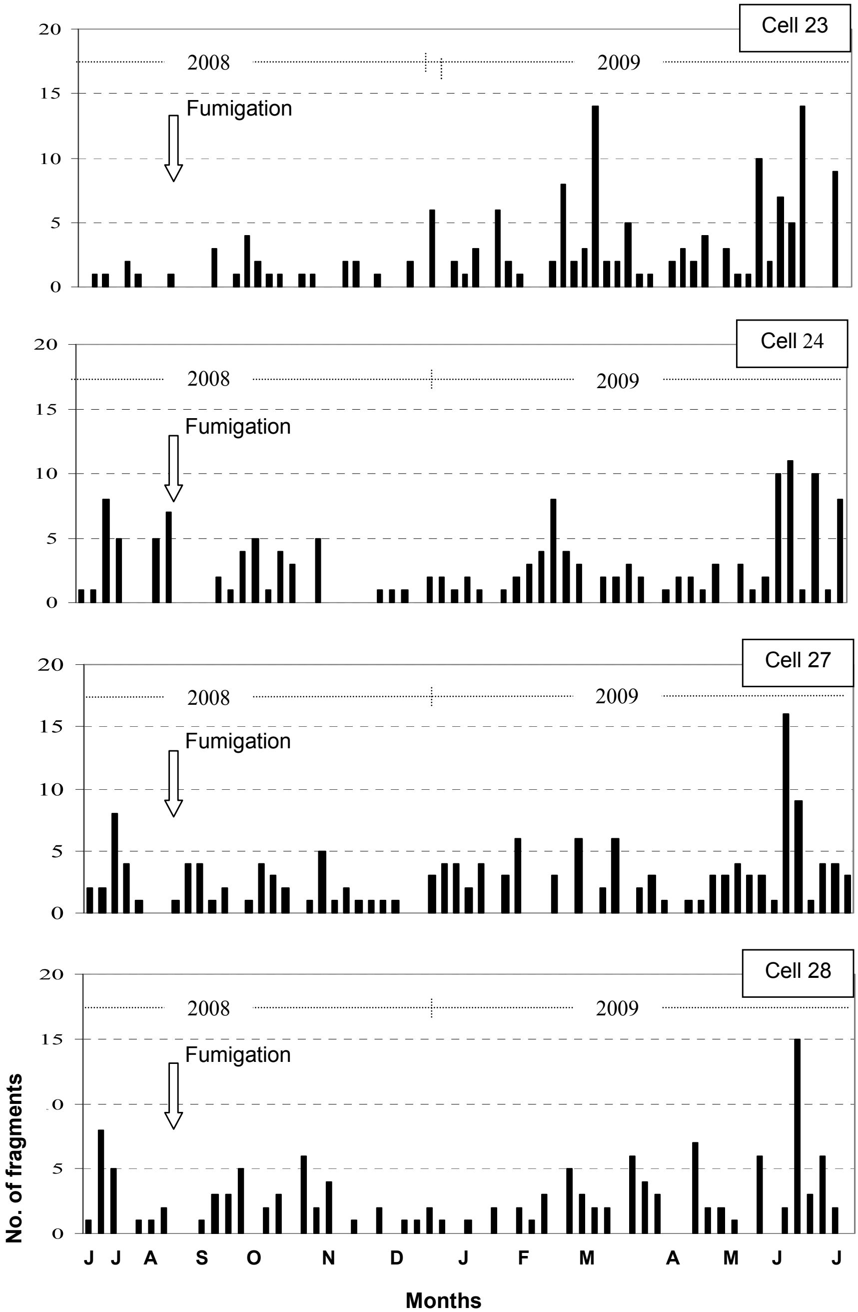

Figure 2 Number of insect fragments recovered in semolina samples separated for each silo considered.

4. Discussion

Our findings obtained during the present light-filth survey work are different from those observed using a monitoring programme based on insect food-trap capture that studied the spatial distribution of insects on the different floors of the same mill (Trematerra et al., 2007). In fact, on that occasion *Tribolium confusum* Jaquelin du Val followed by *Typhaea stercorea* (L.) (Coleoptera: Mycetophagidae) and *Tribolium castaneum* (Herbst) were the most recurrent species found, while *Sitophilus oryzae* (L.) and *Lasioderma serricorne* (F.) (Coleoptera: Anobiidae) were found occasionally; moths were almost entirely absent.

In this regard, it must be remembered that the light-filth method and monitoring realized with traps have different purposes and are used at different points of the grain chain. In fact, in this case the former allows only showed the presence of impurities to be found in the semolina, and therefore, the control that is performed indirectly involves both the stored cereals to be transformed and the milling equipments, including the silos used for semolina storage. On the other hand, traditional monitoring with an insect trap network essentially checks the presence of insects that are in the mill environment and outside the machineries.

Nevertheless, the two different results obtained by monitoring and by the light-filth method point out a diversified and complex situation that suggests a multidisciplinary approach in the control of the infestations in closed circuit of industrial mills, with a need for their integration.

As is known, insect-pest management in Italian and southern European mills is generally founded on structural fumigation with annual or half-yearly frequency and on numerous treatments with contact insecticides achieved especially in the summer period. The monitoring is normally carried out because it is considered useful to get information on the presence of the insect pests. The monitoring data obtained are not often used as support to individualize the actions to be taken to control risky situations before they become real emergencies but are read only as a measurement of the problems to be solved by periodical treatments. Furthermore, the correct importance is not always given to preventive measures against the proliferation of pests (Trematerra and Gentile, 2008).

In our case, the general fumigation of the mill was done on the second week of August, using sulfuryl fluoride with 62 h of exposure. Because of this fumigation treatment, the mill suspended its activities for about 10 d, the period considered necessary for the toxic effects of the gas to decay.

Despite this, observing the temporal distribution of the fragments in the 250 analysed samples, it was underlined that the hygienic and sanitary quality of semolina produced by the mill was nearly unchanged despite the different origins of the cereals processed. This points out that the structural fumigation of the plant did not have positive effects on semolina contamination, considering that although the number of fragments found (and their typology) decreased for several weeks after a fumigation treatment, the number remained almost unchanged from June 2008 to July 2009 (Figure 1).

From a managerial point of view, the qualitative and quantitative indications obtained from the results of the light-filth method put into discussion both the utility of the structural fumigation and the opportunity to effect the fumigation treatment in August, not only due to the negative economic aspects and direct costs of the treatment, but also due to the indirect costs related to the days when the mill did not operate.

Traditionally, the people responsible for mills remedied the missed production time by carrying out the structural fumigation when the mill operations were already stopped, during the summer holidays of the personnel.

In the light of our results, the expenses of the fumigation could be optimized better in the logic of IPM, for instance, by improving the cleaning procedures and carrying out localized insecticide treatments in only the areas affected by infestation, or by adopting alternative technical measures to chemical biocides (Schöller et al., 1997; Mourier and Poulsen, 2000; Fields and White, 2002; Trematerra and Gentile, 2008).

In cereal flour, insects and their fragments originated from primary infestation of the grain before milling and/or from secondary infestation during the storage of flour and flour products on the food processing line. Field pest fragments can be removed from grain by cleaning, immature stages and pre-emergent adults of internal grain-feeding insects may not be removed by cleaning before milling. As a result, these stages are one of the main source of insect fragments in wheat flour. In this regard, several methods have been developed to detect hidden insects in whole kernels. Infestation of grains may be detected by staining of kernels to identify entrance holes for eggs, floatation, radiographic techniques, acoustic techniques, uric-acid measurement, nuclear magnetic resonance imaging and immunoassays (Neethirajan et al., 2007).

Incoming wheat in commercial facilities can be cleaned with entoleters, scalpers, and fluidized bed aspiration before milling. Wheat thrown by centrifugal force inside an entoleter during the cleaning process would likely break hollow kernels, such as those housing large larvae. Broken kernels and newly exposed insects resulting from entoleters would be easily separated from sound kernels. Therefore, no insect fragments from these sources would be evident in the final mill-stream. Unfortunately, not all mills use this type of cleaning equipment. Relative to the abundance of species infesting the mill-rooms (secondary infestation), a possible fumigation treatment should be decided upon monitoring various aspects within the mill to safeguard the health of personnel and operators, and to preserve the quality of finished products. Furthermore, monitoring plans should be implemented opportunely not only to check for presence of infesting animals, but also to furnish valid help with respect to population abundance and spatial-temporal distribution. This information is of extreme importance when it is necessary to decide where and how manage infestations, with the purpose of avoiding periodical chemical treatments, reducing the area and frequency of treatments, and implementing prevention methodologies or alternative methods to the application of insecticides (Athanassiou et al., 2005; Trematerra et al., 2007). In this regard, the critical points of access to the mill, the areas with accumulation of food debris, and the micro-climatic conditions favourable to the development of the infesting pests should be identified.

For a good IPM approach, in situations similar to the ones investigated here, it is necessary to adopt a permanent monitoring activity which will be useful for a meaningful reduction in the use of chemicals. These will be directed localized treatments in areas of higher pest density based on accurate cleaning of the transformation departments, and above all, on a careful choice and inspection of the cereals on their arrival and during the storage period in silos.

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