PAPER

PEST DETECTED IN PACKED FOOD: TEN YEARS OF ANALYSIS

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ABSTRACT

More than one hundred food complaints, coming from food industries, food stores, and customers, were analyzed over a ten-year period (2004-2013). In the samples of plant products and animal products, the prevalent pests were insects and rodents while in animal products, mites were also found. The highest percentages of stored products' pests in plant products were represented by Coleoptera (62.1) and Lepidoptera (48.2), while Diptera were mainly crop pests (12.5) or species of hygienic concern (33.3). In animal products, the highest number of complaints concerned milk and dairy products, and the contaminations were caused by insects, mites, and mice.

Keywords: pests, infestation, products contamination

1. INTRODUCTION

Different types of foreign matter are reported in food, and insects are considered one of the most important foreign matter problems (LEWIS, 1993; EDWARDS and STRINGER, 2007).
As stated by the FDA Defect Levels Handbook (2014), an infestation is: "The presence of any live or dead life cycle stages of insects in a host product, …; or evidence of their presence …; or the establishment of an active breeding population …". An inaccurate use of Integrated Pest Management and of Hazard Analysis and Critical Control Points in food processing and retailing can facilitate the occurrence of pests; the detection of extraneous materials in processed food causes the significant loss of revenue and image to the companies involved.
Animal contaminations can derive not only from crops, food industries, and stores but also from dwellings when food is improperly conserved (TREMATERRA and FLEURAT-LESSARD, 2015). The presence of insect in food repulses customers, and moreover, the presence of pests can cause hygienic problems, e.g. cockroaches, domestic flies and rodents can contaminate food with pathogens (GORHAM, 1991; MACOVEI *et al*., 2008; SULAIMAN *et al*., 2011; PAVA-RIPOLL *et al*., 2012; WASALA *et al*., 2013).
Complaints about cereal products were considered in a previous paper, and the pests most frequently associated with contamination were flying insects. The moth *Plodia interpunctella* (Hbn.) (Lepidoptera, Pyralidae) and the beetle *Sitophilus oryzae* (L.) (Coleoptera, Curculionidae) were the pests that were most commonly responsible for food contamination, and rodent droppings were found in a few cases (SÜSS *et al*., 2014). Pasta was more commonly infested by insects because the strip of cardboard packaging is not always well-glued, and one or two series of aeration holes in flexible packaging allow insect entry (GORHAM, 1991; LOCATELLI and GAMBARO, 1999; SÜSS *et al*., 2014; TREMATERRA and SAVOLDELLI, 2014). *P. interpunctella* contaminated confectionery products, made with ingredients that are susceptible to attack, namely, flour, cocoa, nuts, and dried fruits (SÜSS *et al*., 2014).
In the present study complaints about extraneous materials, such as insects, rodent droppings, and hairs, visible to the naked eye, in plant and animal food source were analyzed.

2. MATERIALS AND METHODS

Samples, coming from food industries, food stores, and customers, were analyzed in the entomological laboratory of University of Milan from 2004 to 2013. In the present study, we analyzed food related complaints of samples belonging to plant products (88), and animal products (16), in a total of 104 samples.
Samples were delivered in original packages, unwrapped packages, or without packages. In some cases, the samples were delivered frozen or cooled. Samples were stored at the temperature of the retail store and analysed within 48 hours.
When the sample was delivered in the original package, the first step in the analysis was a visual inspection to ensure the integrity of the package and the presence of any obvious sign of infestation. The presence of mechanical-related holes, holes due to the activity of insects, or sealing defects, was verified before opening packages. Airtight packages were then verified by immersion in water. Holes were scrutinized under a stereo-microscope to verify if they were of mechanical origin or due to the insect activity (RIUDAVETS *et al*., 2007). Where insects were found, developmental stage and larval age were noted, and we also noted if the insects were dead or alive (SÜSS *et al*., 2014).

For each category, we reported the number and/or the percentage of samples contaminated with insects, rodents or other animals. Insects were classified and divided into two different categories: crop pests and stored product pests.

3. RESULTS

In the samples of plant products and animal products, the most represented pests were insects and rodents (Table 1), while mites were also found in animal products.
Among insects (Table 2), Coleoptera (40.3%) and Lepidoptera (37.5%) were the most represented in plant products, while Diptera (33.3%) were in animal products. Only 15.2% of plant product complaints concerned food in opened packages, while animal product complaints mainly concerned unwrapped packages.

Table 1: Percentages of pests in samples of plant products (88) and animal products (16).

Pests	Plant products	Animal products
Insects	81.8	70.5
Mites	-	11.8
Anellida	1.1	-
Rodents	11.4	11.8
Other vertebrates	1.1	-
Other contaminants*	4.6	5.9

*plastic fragments, feather, seed and vegetable debris.

Table 2: Percentages of insect Orders present in samples of plant products and animal products.

Insect	Plant products	Animal products
Coleoptera	40.3	25.0
Lepidoptera	37.5	16.8
Diptera	12.5	33.3
Hymenoptera	-	8.3
Thysanura	1.4	-
Orthoptera	1.4	-
Dermaptera	1.4	8.3
Dictyoptera	1.4	-
Hemiptera	1.4	8.3
Psocoptera	2.7	-

3.1. Plant products

In complaints about plant products, pests of stored products represented the highest percentages in Coleoptera (62.1) and Lepidoptera (48.2), while Diptera were mainly crop pests or species of hygienic concern (Table 3).
Fruits and vegetables (21.6%), canned vegetables (18.2%), and cocoa (15.9%) were the foods most susceptible to complaints (Table 4) followed by frozen vegetables (11.4%), mushrooms (9.1%), ready to eat fresh vegetables (7.9%), and fresh vegetables (4.5%).

Table 3: Complaints about plant products: relative values of Lepidoptera, Diptera and Coleoptera (each Order was considered 100) distributed according to origin of pests (in the case of "other", Lepidoptera pests were unidentified, in the case of Diptera pests were of hygienic relevance).

Origin of pests	Lepidoptera	Diptera	Coleoptera
Crop	37.0	66.7	37.9
Stored products	48.2	-	62.1
Other	14.8	33.3	-

Table 4: Number and percentage of complaints about different food plant products.

Food	Complaints	
	No.	%
Canned vegetables	16	18.2
Cocoa	14	15.9
Dried fruits and vegetables	19	21.6
Frozen vegetables	10	11.4
Fruit juice	2	2.3
Grinded coffee	1	1.1
Mushrooms	8	9.1
Olive oil	2	2.3
Ready meals	1	1.1
Ready to eat fresh vegetables	7	7.9
Sugar	2	2.3
Vegetable stock cube	2	2.3
Vegetables	4	4.5

Among crop pests, noctuid moths larvae or locusts were found in salads and spinach, *Acanthoscelides obtectus* Say, *Callosobruchus maculatus* (F.) and *Zabrotes subfasciatus* (Bohemann) (Coleoptera, Chrysomelidae) infested dried and canned pulses, *Tuta absoluta* (Meyrick) (Lepidoptera, Gelechiidae) and elaterid larvae were detected in tomatoes, Noctuid larvae were found also in canned artichokes and tomatoes, and elaterids in canned jam. *Ostrinia nubilalis* (Hübner) (Lepidoptera, Crambidae) contaminated grilled

peppers, while Carabidae, ground beetles, were detected in spinach and also in chamomile.
Alive stored product pests such as *Lasioderma serricorne* (F.) (Coleoptera, Anobiidae) developed in chamomile, spices and herbal tea, *Plodia interpunctella* infested cocoa products, and nuts and dead larvae of *P. interpunctella* were found in coffee, vegetable stock cube, and instant mashed potatoes. In cocoa products, *Ephestia* spp. (Lepidoptera, Pyralidae) were also detected, and accidental contamination by blow flies, *Forficula auricularia* L. (Dermaptera, Forficulidae), and *Attagenus* sp. (Coleoptera, Dermestidae) was observed; the presence of *Ahasverus advena* (Waltl) (Coleoptera, Silvanidae) and *Carpophilus* sp. (Coleoptera, Nitidulidae) in cocoa beans revealed the presence of molds.
One adult psocid (Psocoptera), probably present in the cupboard, contaminated an open sugar bag while another was detected in a bottle of olive oil.
Sometimes, species not directly linked to the food were found, but their presence seriously increases the risk of contamination, particularly with regard to insects of hygienic relevance. Examples were one larva of *Musca domestica* L. (Diptera, Muscidae) and one adult of *Muscina* sp. (Diptera, Muscidae) in tomato sauce and a *Periplaneta americana* (L.) (Dictyoptera, Blattidae) nymph in dried mushrooms.
Occasional infestations caused by larvae of *Attagenus* sp. (Coleoptera, Dermestidae) in an orange soft drink and in fruit juice, blow fly in cocoa, and by parts of other animals, such as one lizard tail, one earthworm, and one feather, were also detected.
Mus domesticus Schwartz & Schwartz (Rodentia, Muridae) contaminated different foods: dead mice were found in the cocoa bean, in frozen vegetables, in tomatoes and potatoes. Legs of mice and one *Apodemus* sp. (Rodentia, Muridae) were also present in spinach. Also, droppings of mouse were detected in sugar, oil, and sesame seeds, while mouse hairs were found in dates.

3.2. Animal products

In the case of food complaints in animal products the packages were already unwrapped, except for eggs. The highest percentage of complaints concerned milk and dairy products (62.5%) and the contaminations were caused by insects, mites, and mice. In detail, one adult of Diptera Sciaridae contaminated a milk bottle, while different insects were detected in dry milk: larvae of dermestid and anobid beetles, and the thorax of an adult stink bug, *Forficula auricularia* (Dermaptera, Forficulidae), was found in fruit yoghurt. Cheese was contaminated with *Tyrophagous putrescentiae* (Schrank) (Acarididae, Acaridae) mites, but also with plastic debris. In dry milk, an adult of *M. domesticus* was found, while droppings were detected in cheese.
Diptera were also found in salami, one blowfly larva, and one muscid pupa in an egg package.
Only in one case was a larva of *P. interpunctella* recorded in a meat product: this involved a breadcrumbed chicken breast and the infestation derived from the breadcrumb.
As far as fish products are concerned, one larva of *Tenebrio molitor* L. (Coleoptera, Tenebrionidae) was in canned tuna, one larva of *M. domestica* was in canned octopus, and one larva of an unidentified moth was in fish baby food.

4. COMMENTS AND CONCLUSION

Food infestation mainly concerned insects and rodents to a lesser extent. Crop insects were frequently detected in frozen and ready to eat vegetables, as the pest hides in the vegetable and leaves are sometimes difficult to wash due to their conformation.

Vegetable food samples included wrapped and unwrapped packages while complaints about animal products were always about already unwrapped packages. This case makes it difficult to exactly state the origin of contamination, but it should frequently be ascribed to improper conservation after purchase.
Plodia interpunctella was the most frequent pest; it infested cocoa products, dried and dehydrated vegetables, dried beans, chamomile, spices and herbal tea, nuts, coffee, vegetable stock cubes, instant mashed potatoes, and was also recorded in breadcrumbed meat.
Ready to eat products with dried mushrooms were infested by dead larvae of Diptera Mycetophilidae. Fungus gnats avoid already senescent or decaying mushroom, usually spoiled by Diptera Phoridae, Sciaridae, and Calliphoridae (LOCATELLI *et al*., 2006). Therefore, the presence of Mycetophilidae indicated that the mushroom was fresh.
Ahasverus advena and *Carpophilus* sp., which infest nuts and dried fruits that are incorrectly stored (WOODROFFE, 1962), were detected in cocoa beans; their presence reveals the development of molds (SINHA, 1974; PIERCE *et al*., 1991) that can produce mycotoxins (DAVID *et al*., 1974). Also, cockroaches and flies in food cause concern as they are linked to the transmission of pathogens (SASAKI *et al*., 2000; DE JESU´S *et al*., 2004; TALLEY *et al*., 2009).
In a few cases, the infestation was caused by different live insect stages; often, only one dead insect was detected in the samples. In a previous paper on cereal products (SÜSS *et al*., 2014), live insects in different stages were detected. This time, few live insects were in dried food such as chamomile, cocoa, nuts and herbal tea.
Rodent droppings and hair were found both in plant and animal food. Rodent contamination is unacceptable for health reasons (MEERBURG and KIJLSTRA, 2007) and indicates negligence and laxity in applying prevention measures during production and storage in warehouses and dwellings. Sometimes, customers confused soil and pieces of plastic with droppings.
Some pests not typically associated with the products were also found. Larvae of *P. interpunctella* often nestled under lids and in jars. In these cases, the insects used the packaging as a shelter, but the effect on the customer was nevertheless extremely negative. In other cases, the insect was embedded in the multilayer film, as sometimes packaging industries overlook insect prevention in processing departments (RIUDAVETS *et al*., 2007). An integrated approach of controlling food safety throughout the entire food production chain has become an important issue in attaining a greater food safety level (VALEEVA *et al*., 2004; TREMATERRA, 2013; TREMATERRA and FLEURAT-LESSARD, 2015).
Quality assurance of food industries asks entomologists about the identification of pests' species, and information on biology and ethology of pests in order to establish the weak point of production processes. In the majority of our cases, it was not possible to trace the origin of infestation. Consumers frequently reported contamination several days or weeks after purchase, i.e. packages have already been opened (sometimes a part of the package was missing) and part of the food has been consumed. As TURNER and ALI (1996) reported, often products which are left, partially used and open, in a cupboard will absorb water vapor and possibly become attractive to psocids in the kitchen. In many cases, no information was available about storage conditions after the packages were opened.

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Paper Received April 12, 2015 Accepted December 20, 2016