

soon, as the last insecticide for direct treatment of grain, malathion, is no longer available in Denmark. The only options now are fumigation with hydrogen phosphide or treatment with inert dust. Possible future climate change with higher temperatures and higher humidity may lead to increased problems due to pests in stored grain.

Flour mills: The pests found in other stored products in the processing chain are similar to the rest of Europe, as temperature and humidity conditions are less correlated with outdoor conditions. In flour mills the main pests are *Ephestia kuehniella* and *Tribolium confusum*. Pest problems are managed by a combination of sanitation and application of residual pesticides and pyrethrin fogs. Heat treatment and application of inert dusts are not used very much.

Wholesale and retail stores: In this sector the pests are the same as in other EU countries. However, during recent years *Plodia interpunctella* has become more common in private households. The consequences of this on human health are unknown, but it could represent a problem due to adverse effects of fragments from *Lepidoptera* (allergies resulting from presence of wing scales and fragments in the immediate environment and human food).

A description of the pest situation in stored products in several EU countries can be found in the proceedings from several meetings of COST Action 842, WG IV: Bio-control of arthropod pests in stored products, available at <http://cost842.csl.gov.uk/>

23 - Stored Product Protection Perspectives in Spain

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Abstract

There is an important food industry in Spain that represents the main industry sector, accounting 16.2% of net product sales and 14.6% of industrial employment. Consumption of many types of cereals, dried fruits and nuts, legumes and spices in Spain is very high as they are a component of our traditional food. A number of these food products could be stored after the harvest season for more than 3 months, and be processed little by little during the year. The storage of imported commodities is similar except for those products with high demand that are commonly processed in a period of 1-month or less. Both silos and warehouses are used for the storage of raw material and final food products. A number of pest species can affect both commodities and processing facilities, among them several Coleoptera, Lepidoptera, Psocid and Mite species. Chemical control based on residual insecticides and fumigants is the most common pest control method used. In Spain, there are a limited number of active compounds that are allowed to use for stored pest control. As a consequence pesticide resistant insect strains are already present in some areas. Treatments are concentrated in summer when temperatures are optimal for insect development. Among pesticides, phosphine has replaced in most cases the use of methyl bromide after its phase out. There is an increasing use of prevention, hygiene, monitoring of pests and alternative control methods. HACCP protocols and IPM are followed by a number of companies. Other methodologies in use are Modified Atmospheres for both fumigation or packaging and, CO₂ at high pressure for treating spices and herbs. Biological control is not used and still not known as an alternative control method by the agro-food industry.

Keywords: Stored Products, Pest control, Chemical Control, IPM.

Introduction

Value of market including imports and exports: There is an important food industry in Spain that represents the main industry sector, accounting 16.2% of net product sales and 14.6% of industrial employment (Ministerio de Medio Ambiente y Medio Rural y Marino, 2009a). Consumption of many types of cereals, dried fruits and nuts, legumes and spices in Spain is very high as they are a component of our traditional food.

In Spain there are about 220 mills and 15,000 bakeries. The number of mills has gradually decreased during the last 10 years due to a reorganization of the sector and the merge of companies trying to re-duce competitiveness. Milling capacity of the Spanish industry is approximately 27,000 tons of wheat per day. However, flour production is about 2,7 millions of tons per year, thus only 40% of the total milling capacity. This low productive capacity is caused by sales and exports cuts during the last years. The consumption of bread per capita (58 kg approximately) has also decreased during the last 20 years. There is also an important dried fruit industry in Spain. The main commodities produced are almonds, hazelnuts, chestnuts, figs and carobs (Table 1). Spain is the second largest almond exporter (45,000t/year) and the fourth largest hazelnut exporter (4,600t/year) in the world. Both commodities represent a trade value of more than 200 million euro. There is a high quantity of imports of dried

fruits and nuts such as almonds (35,000t/year) and hazelnuts (5,000t/year). In Spain there are more than 100 private exporter companies, 95% of those with international standard quality certification (ISO 9000).

Tab. 1 Dried fruits and nuts produced in the world, Europe and Spain.

	Production (t/year)			% Spain vs.	
	World	EU	Spain	World	EU
Carobs	186,817	141,700	72,000	38.5	50.8
Almonds	2,065,489	385,686	201,100	9.7	52.1
Hazelnuts	776,890	160,641	17,600	2.3	11.0
Chestnuts	1,223,385	125,990	10,000	0.8	7.9
Dates	6,422,325	5,250	5,250	0.1	100
Figs	1,062,473	103,400	38,000	3.6	36.8
Walnuts	1,694,889	159,089	10,000	0.6	6.3

Source: FAOSTAT ProdSTAT (2007)

Processing and retail trade of spices and aromatic and medicinal herbs have a long tradition in Spain. Nowadays, more than 400 different species of spices and herbs and more than 350 essential oils and extracts from these herbs are used. Spanish imports rank the 5th European country and the 12th in the world. According to the WHO, medicinal plants alone represent 138 million € in Spain.

Storage of raw and processed materials: For cereals, both silos and warehouses are used for the storage of raw material. Flour is not stored after its production. A majority of mills use to send the flour to their customers within the first week. However, in some cases part of flour production could be stored for a maximum period of 3 months. For legumes and dried fruits, warehouses, silos and big bags are used for the storage of raw material. Most companies and cooperatives use refrigerated chambers (5 to 12°C) for the storage of both commodities during the warm seasons to prevent increases in insect pests. The largest part of legumes, nuts and dried fruits are stored after the harvest season for more than 3 months. They are processed little by little during the year. The storage of imported commodities is similar except for those products with high demand that are commonly processed in a period of 1-month or less. Aromatic herbs and spices are stored in bags, big bags and boxes in warehouses and refrigerated chambers. Raw materials are stored for long periods of more than 3 months.

Pest problems found: Thirty species of arthropods representing six orders and 15 families are the most important pest of stored products in Spain (Riudavets et al., 2002). Orders with the greatest number of species are Coleoptera and Lepidoptera. Among pests, the rice weevil, *Sitophilus oryzae* (L.) and the lesser grain borer, *Rhyzopertha dominica* (F.) are the most abundant species in stored cereals. The cigarette beetle, *Lasioderma serricorne* (F.), the drugstore beetle, *Stegobium paniceum* (L.), the flour beetle, *Tribolium castaneum* (Herbst) and *T. confusum* Jacquelin du Val, the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), the Indian meal moth, *Plodia interpunctella* (Hübner) and the flour moth *Ephestia* sp. are the most numerous and widely distributed species in wheat flour, dried fruits, spices and medicinal herbs. The bean weevil, *Acanthoscelides obtectus* (Say) and other Bruchidae species are abundant in legumes. Several species of mites are present in wheat semolina and final food products, but always related with high humidity conditions. Psocids, an increasing problem worldwide, are collected in high number in grain, semolina and other cereal by-products, but also in herbs and spices. In addition, four species of parasitoid Hymenoptera are found in food facilities, among them the pteromalids *Anisopteromalus calandrae* (Howard) and *Lariophagus distinguendus* (Foerster), the Ichneumonidae *Venturia canescens* (Gravenhorst) and the Braconidae *Habrobracon* hebetor (Say). The predatory mite *Blattisocius tarsalis* (Berlese) is also present in silos of grain and legumes.

Pesticides used: Chemical control based on insecticides and fumigants is the most common pest control method used. Although some chemical pesticides could be considered for controlling pests, Spain recognizes only a limited number of active compounds for controlling pests affecting stored products (Table 2). As a result, food facilities and commodities must be repeatedly treated with the same insecticides. Treatments are concentrated in summer when temperatures are optimal for insect development. Some companies also apply chemical treatments on a calendar based schedule. This implies a potential risk of insect resistance, making pest control more difficult or even ineffective.

Chlorpyrifos-methyl, Pirimiphos-methyl, Deltamethrin and Natural Pyrethrins are registered for commodity treatment, i.e. cereals and legumes. Pirimiphos-methyl and Natural Pyrethrins are registered for space treatments against crawling and flying insects. Phosphine (PH₃) (Magnesium Phosphide and Aluminium Phosphide) is a fumigant registered for the control of pests in a number of stored food products. Even so, PH₃ cannot be considered as an alternative to MB. In comparison with MB, PH₃ needs much longer treatment times to effectively control pest (i.e. *S. oryzae*, 12 days for non-resistant insects at 20-30°C, EPPO 1998). Sulfuryl Fluoride (SO₂F₂) is registered as

a biocide for flying and crawling insects. It is classified as toxic and dangerous for the Environment. It is used exclusively for the treatment of sealed premises, isolated from houses or inhabited buildings. Dosage and application has to be according to the FUMIGUIDE software and type of premise, temperature, exposition time and pest species, with a maximum dosage of 1500 g-h/m³ (31,25 g/m³ 48h). Furthermore, it is not permitted to use insecticides as part of treatments applied to final products.

Tab. 2 Pesticides registered in Spain

Active compound	Formulation	Dosage	Commodity / Structures	Pest
Methyl Clorpiriphos	22.4% (EC)	10 cc/T	Barley, Wheat, Maize	<i>Ephestia, Oryzaephilus, Rhizoperta, Tribolium</i>
Deltamethrin	0.6% (UL) 0.2% (DP)	40-80 cc/T 250-500 g/T	Cereals, Legumes	SP pest
Methyl Pirimiphos	2% (DP)	1.25kg/100m ³ 400g/T	Space treatment Cereals	SP pest
Pirethrin	50% (EC) 0.8% (DP) 5% (EC)	100mL/100m ² 0.5-0.75kg/T 6.5%	Space treatment Cereals Space treatment	Weevils, Months SP pests
	6% (EC)	1L 4% /T 5.5%	Cereals, Legumes Space treatment	Weevils, Months SP pests
		1L 3.3% /T	Cereals, Legumes	Weevils, Months
Pirethrin + BPO	0.2% + 2% 5% + 50%	1kg/T 6.5%	Cereals, Legumes Space treatment	SP pest, Weevils, Months SP pest, Flies
		1L 4% /T	Cereals, Legumes	Weevils, Months
Aluminum Phosphide	57% (0.6g/Pellet)	15-25 Pellet/T	Peanuts, Cacao, Spices, Cereals, Legumes, Equipment, Bags, Tobacco	SP pests
	57% (3g/Tablet)	3-5 Tablets/T		
	57% (34g/Bags)	1 Bag/2-3m ³		
Magnesium phosphide	56% (117g/Plate)	1 Plate/6-10m ³	Cacao, Spices, Dried fruits, Cereals, Wheat	SP pests
	66% (3g/Tablet)	3-5 Tablets/T	flour, Legumes, SP, Seeds, Tobacco, Bags	

Source: Ministerio de Medio Ambiente y Medio Rural y Marino, (2009b)

Pesticides must be exclusively applied by authorized pest control companies and qualified pest control technicians. There are three levels of authorization depending on the toxicity of the product and the people involved in treatment: basic, qualified and special. Basic and qualified levels are addressed for people applying pesticides classified as non-very toxic. For those who have passed the tests of basic or qualified levels that determine the field of accredited training, is considered a special level for highly toxic products. Training is not only addressed to professionals' users but to distributors and advisers. The training program covers: IPM strategies and techniques, use, equipment maintenance and application techniques, legislation on pesticides, risk and hazard of pesticides, emergency measures for human and environment safety and registration of PPP.

Other control measures or IPM used: Although the main control method is still based on chemicals, there is increasing use of prevention, hygiene, monitoring of pests and alternative control methods. HACCP protocols are followed for most of the companies. However, IPM is a term under discussion since HACCP is covering most of the tools issued from the IPM concept. According to the HACCP protocols chemical control is usually the main tool for prevention and control of insects in contradiction with the IPM concept.

Among prevention techniques to avoid insect and mite development, aeration and refrigeration of grain in silos and warehouses and the storage of several commodities such as legumes, dried fruits and spices in cold chambers are increasingly used.

Heat treatments are used sporadically for the treatment of pallets and other packaging materials. When quarantine and pre-shipment treatments are applied, MB is still generally used. Heat treatments for space disinfestations and structural treatments in mills and other food facilities are not in practice in Spain, in comparison to other EU countries and the USA where it is increasingly applied. Poor insulation, thin walls and the presence of windows in most of the facilities might be a barrier to the implementation of this technology.

Cryogenic cleaning with pellets of CO₂ to remove food residues that act as a refuge for pest in machines and hiding places is an alternative used in some food facilities. Diatomaceous earths are registered as a food additive. However, their use is not widespread.

Biological control is not used and still not known as an alternative control method by the agro-food industry. However, natural enemies, parasitoids and predators, are abundant and present throughout the whole year in the food factories in Spain. They are not only present in organic food factories but in factories applying chemical control. This is probably due to the presence of refuges where chemical insecticides cannot reach.

More recently, companies are considering the use of some plant extracts containing bioactive compounds as repellents or to prevent insect development. Substances must be considered as safe (GRAS) and are normally blended with the final product or integrated in the packaging materials as a barrier to prevent cross contaminations.

Controlled or Modified Atmospheres are increasingly in use for either fumigation of commodities or packaging of final food products. Modified atmosphere treatments are safe and environmentally friendly ways of controlling pests that affect a large number of raw and manufactured food products. Application of high CO₂ modified atmospheres have tended to focus on the control of pests affecting raw or semi-processed food products in silos and warehouses as an alternative to using conventional chemical fumigants and insecticides. However, this technology is also being applied to final products during the packaging process, to prevent the development of pests that are found after the manufacturing process. Modified atmospheres are used with consumer packages that involve the use of modified flow pack machinery, when storing intermediate food products into large big bags or when preparing final products for pallet storage. Modified atmospheres are equally flushed into either small (1 kg) plastic packages or large (1000 kg) big bags. Different types of plastic film are available and these offer different barrier properties for gases and make it possible to maintain a given gas mixture throughout the treatment. CO₂ at high pressure for treatment of spices and herbs and vacuum packaging for rice and dried fruits are two technologies now established in a number of processing companies.

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24 - Reaction of Polish industry to reduction of pesticides suitable for stored product protection

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Abstract

Methyl bromide (MB) had been widely used for fumigation of durable commodities, perishable products, structures and transport vehicles. This good gaseous pesticide may not be replaced by one alternative, but various methods and means have to be used. Contact insecticides may be used as MB alternatives on stored grain and in storage structures and food production plants. These insecticides are applied directly to grain during handling on grain conveyors and elevators, or sprayed onto the surface of bag stacks, walls and floors of empty structures and transport vehicles. Spaces of structures are sometimes treated by "fogging" to control of flying insects. However, the number of available contact insecticides was recently limited by the Directive 91/414/EEC and the others will be restricted in the EU by a new Thematic Strategy on Pesticides. Thus, the following measures are currently used in Poland: (a) phosphine, (b) a few contact insecticides, (c) heat, (d) high pressure and CO₂, and (e) Integrated Pest Management (IPM). The most important mean is phosphine (PH₃) from solid phosphides. The following techniques for application of solid phosphides were adopted: (a) Speedbox, (b) dispenser technique, (c) phosphine recirculation system (J-System). Speedboxes seems to be popular in Poland as handling and maintenance of them is