

# Stored agricultural product protection in Croatia

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## Abstract

About 150 species of harmful insects and 30 species of mites are known on the stored-grain products of the European Republic of Croatia.

Most of them are economically important pests and they damage 2–3% of public sector product and 6% of products from small private farms. The most important are *Sitophilus granarius* (L.), *Sitophilus oryzae* (L.), *Sitophilus zeamais* Motsch., *Rhyzopertha dominica* F., *Plodia interpunctella* (Hubn.), *Sitotroga cerealella* (Oliv.) (primary pests), but the most numerous are *Cryptolestes ferrugineus* Steph., *Oryzaephilus surinamensis* L., *Tribolium confusum* (Du Val.), *Tribolium castaneum* (Herbst) (secondary pests).

Very frequent are psocids: *Liposcelis corrodens* (Heym.), *Liposcelis pubescens* Brhd., *Liposcelis paetus* (Pearm.), *Liposcelis bostrychophilus* Bad., *Liposcelis entomophilus* (End.), *Liposcelis simulans* Brhd., *Liposcelis kidderi* (Hag.), *Liposcelis mendax* Pearm., *Liposcelis tricolour* Bad., *Liposcelis terricolis* Bad., *Lepinotus recitulatus* End., *Lepinotus inquilinus* (Heyd.), *Psyllipsocus ramburi* Sel. var. *destructor*, and *Lachesilla pedicularia* (L.).

The most abundant mites are *Tyrophagus putrescentiae* (Schrank) and *Acarus siro* (L.). The nematode *Anguina tritici* (Steinb.) Chitwood is an economically important pest of stored wheat at a few private farms, but is successfully controlled.

Pest protection is based mostly on prevention but chemicals are applied as a last measure in order to decrease food and forage contamination. The registered active ingredients used are: dichlorvos, chlorpyrifos-methyl, pirimiphos-methyl, malathion, deltamethrin, phosphine, methyl bromide and hydrogen cyanide. The most frequently applied compounds are dichlorvos, pirimiphos-methyl and phosphine.

## Introduction

Agriculture in the Republic of Croatia is a very important part of the country's economy. Crops are grown on both big agricultural enterprises (public sector holdings with 25% arable land) and on small private farms of average size of 2.9 ha with 75% arable land. Farming crops include cereals (wheat, maize, barley, oat, rye), oil plants (sunflower, soybean, rape), industrial plants (sugar beet) and forage (lucerne). Plant yields on public sector holdings are close to European standards, whereas on private farms they are considerably less. Enough is produced for domestic consumption, and small quantities are exported. Agricultural products are kept in store houses with a total of over 2 million t of storage capacity. Storage facilities include constructed store houses (60%), silos (24.4%), hangars (5.9%), wire baskets for corn cobs (1.9%), cellars

(2.9%), refrigerated warehouses (2%), prefabricated store houses (1.9%) and other warehouses (0.8%).

On public sector holdings products are stored in silos and large or small store houses, while on private farms corn cobs are stored in wire baskets and in little floor warehouses. In all stored products in these conditions, harmful insects, mites and nematodes appear and cause losses amounting to about 2–3% in public sector store houses and about 6% in store houses on private farms.

## Materials and Methods

This paper reports the results of investigation into harmful insects, mites and nematodes in silos and large floor store houses of public sector holdings, in stored mercantile and seed goods (wheat, barley, oat, rye, maize, sunflower, soybean and rape). In private farm store houses (wire baskets for corn cobs, small floor store houses) research has been carried out on wheat, barley, oat as well as on corn kernels and corn cobs.

Samples have been taken in silos from the top side of bins using 1.5 m sampling spears, by releasing product from the outlet at the bottom of the bin or during transfer of product at definite time intervals.

Samples have been taken by longer or shorter hand spears from spilled products in floor store houses. Corn cobs from wire baskets have been taken from surface and depth. Samples were taken every one or two months during season storage. In total over 5000 samples were taken, each weighing 250 g.

Samples were sieved by automatic apparatus (sieve diameter 0.5–2.5 mm). Insects and mites were separated from sieved material. Coleoptera and Lepidoptera were identified with stereo microscope by keys (Korunic 1990; Schmidt 1970). Psocoptera were preserved in 70% alcohol, cleared, mounted on slides and identified using keys of Gunther (1974) and a phase contrast microscope. Mites were preserved in 70% alcohol and were determined by keys (Pagliarini 1979; Zdarkova 1967) by microscope.

Sample humidity was measured by different apparatus (Twin tester, Dicky John and similar).

Samples of wheat seed from different store houses were analysed. Small and dark seeds were crushed in a drop of water and the larval stages of *Anquina tritici* were identified under the microscope.

## Results and Discussion

### Public sector store houses

In the Republic of Croatia 89% of agricultural production is stored in public sector store houses, that is, in 1148 silos with a combined capacity of 1548000 t and in large floor store houses with a capacity of ca 595000 t, where mercantile and seed wheat, maize, barley, oat, sunflower, soybean and sugar beet are stored. Research into these products has led to the discovery of numerous species of harmful insects and mites (Table 1 and Fig. 1). Representatives of secondary insect species were most numerous in silos—*Cryptolestes ferru-*

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**Table 1.** Pests in store houses (%).

Kind of pests	Public sector			Private sector	
	Silos	Large store houses	Small store house	Small store house	Wire baskets
<i>S. granarius</i>			26.5		
<i>S. oryzae</i>	9.3	19.2	5.3		
<i>S. zeamais</i>	8.5	15.7	4.0		
<i>R. dominica</i>	6.8	12.2	5.3		
<i>C. ferrugineus</i>	17.0	3.9	4.0		
<i>O. surinamensis</i>	10.2	4.4			
<i>T. confusum</i>	15.3	3.5	6.0		
<i>T. castaneum</i>			6.6		
<i>A. advena</i>		2.6			11.3
<i>P. interpunctella</i>	3.4	7.0	10.6		37.7
<i>S. cerealella</i>	2.5	5.2	18.5		22.6
Psocoptera (genus <i>Liposcelis</i> , <i>Lepinotus</i> , <i>Psyllipsocus</i> , <i>Lachesilla</i> )	8.7	17.4	8.0		18.0
<i>T. putrescentiae</i>	5.1	3.9			3.8
<i>A. siro</i>	3.4	5.2	5.3		5.7

*gineus*, *Tribolium confusum* and *Oryzaephilus surinamensis*, which feed on the damaged and broken parts of grain. Investigations showed that during one year of storage 4.68% mechanically damaged and broken grains emerged on wheat, and 10–12% on maize (Kalinovic 1990). Seed damage and broken grains emerge during combining, drying and the manipulation–elevation of products during the storage season. Stored seed in silos is elevated on average two to three times, causing seed brokage and providing a convenient medium for secondary pest growth.

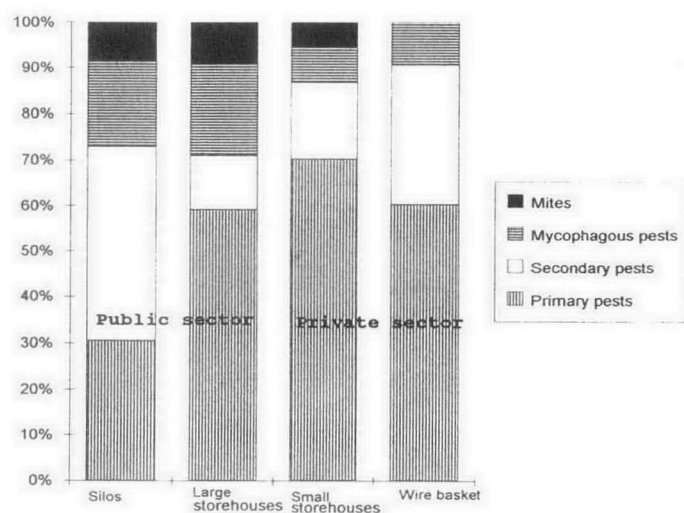
Primary species most abundant are *Sitophilus oryzae*, *S. zeamais* and, *Rhyzopertha dominica*; thermophilic pests which grow in large quantities of stored products, particularly where temperatures are elevated. Representatives of Lepidoptera—*Plodia interpunctella* and *Sitotroga cerealella*—were less prevalent in silos, and seemed to prefer the surface of products stored loose or in sacks in large floor store houses (Kalinovic 1985, 1986a; Kalinovic et al. 1990). Insects of order Psocoptera, mostly representatives of the genus *Liposcelis*—*Liposcelis corrodens*, *L. pubescens*, *L. paetus*, *L. bostrychophilus*, *L. entomophilus* and *L. simulans*, were also present. *L. kidderi*, *L. mandax*, *L. tricolor*, *L. terricolis*, were most abundant on stored wheat and maize, with humidity from 17–21% and temperature from 14–28°C (Kalinovic 1979).

Favourable conditions for these insects include elevated humidity and temperature, as well as the presence of microorganisms, fungi and bacteria, on which they feed with. (Kalinovic et al. 1978). Psocoptera are harmful insects, since their mass presence pollutes products, especially packed food products (Kalinovic 1984). Mites, *Tyrophagus putrescentiae* and *Acarus siro*, emerged sporadically, more in silos and less in large floor store houses, especially in grains (wheat, barley) which hadn't been dried before storage. Mites appeared on seed barley, but timely control measures prevented significant damage and loss of germination (Ilic et al. 1967).

In uncontrolled storing conditions, for example on maize in large floor store houses, *Ahasverus advena* (a mycophagous species) was noted (Ilic et al. 1975).

**Private store houses**

Private store houses in Croatia occupy about 11% of total store house capacity for agricultural products. These are small



**Fig. 1.** Pests of stored grain by type of store house.

floor store houses and hangars, wire baskets for corn cobs, and cellars. The total stored capacity of private store houses is about 263 000 t, an average of 5–8 t per household.

Stored maize, barley and oats are used as feed for domestic animals on farms, whereas wheat is kept to be made into flour either in public or private mills. Private store houses are generally unsuitable for extended storage because they are of poor construction, and farmers are mostly unaware of safe storage practices. Consequently private storage facilities are frequent sources of stored pests.

Pests in products stored in private facilities are summarised in Table 1 and Figure 1. In small floor store houses, the most common primary pests were *Sitophilus granarius* and representatives of Lepidoptera—*S. cerealella* and *P. interpunctella*—which in uncontrolled conditions caused significant damage on stored wheat, barley and maize. Secondary species included *Tribolium castaneum*, *T. confusum* and *Cryptolestes ferrugineus*. These species were less abundant and they appeared as primary pest species escorts. Representatives of Psocoptera—*Lepinotus reticulatus* and *L. inquilinus*

**Table 2.** Implementation of stored-product protection measures in the public and private sectors in Croatia.

Protection measure	Public sector		Private sector	
	Silos	Large store houses	Small store houses	Wire baskets
Hygienic measures	+	+	+	+
Physical measures				
Seed cooling	+			
Air conditioning	+	+		
Enriched CO <sub>2</sub> atmosphere—the possibility of application is still being studied				
Inert dusts	Laboratory test ing			
Biological measures				
Chemical measures	+	+	+	
Active ingredient				
Dichlorvos	+ <sup>a,b</sup>	+ <sup>a</sup>	+ <sup>a</sup>	
Chlorpyrifos-methyl	+ <sup>b</sup>	+ <sup>b</sup>		
Pirimiphos-methyl	+ <sup>a,b</sup>	+ <sup>a</sup>	+ <sup>a</sup>	
Malathion	+ <sup>a</sup>	+ <sup>a</sup>	+ <sup>a,b</sup>	
Deltamethrin	+ <sup>b</sup>	+ <sup>b</sup>		
Phosphine				
(Al-phosphide)	+ <sup>b</sup>	+ <sup>b</sup>		
Mg-phosphide)	+ <sup>b</sup>	+ <sup>b</sup>		
Methyl bromide	+ <sup>a</sup>			
Hydrogen cyanide	+ <sup>a</sup>			

<sup>a</sup>Treated empty storages. <sup>b</sup>Product treatment.

appeared sporadically. Mites (*Acarus siro*) emerged after harvesting and occurred in products stored without drying. They disappeared later during the storage season (Pivar et al. 1977). Most abundant were representatives of Lepidoptera—*P. interpunctella* and *S. cerealella*—which emerged in wire baskets for corn cobs, especially in the autumn and spring months.

On stored mouldy corn cobs, Psocoptera representatives—*L. corodens*, *Psyllipsocus ramburi* var. destructor and *Lachesilla pedicularia*—as well as mycophagous species *A. advena* were also numerous. In autumn, corn cobs are stored with seed humidity from 24–28% and by natural drying seed humidity decreases to 15–16%, but not until April the following year.

The most damage to stored corn cobs in wire baskets has been done by rodents—rats, *Rattus norvegicus* (Burk), and mice of *Mus musculus* (L.) species.

The nematode *Anquina tritici* was identified on a few wheat samples from private facilities that used their own seeds for sowing. The law of plant protection in Croatia requires control of this nematode. In areas which are infested by ‘ear cockle’ of wheat (*A. tritici*) farm hygiene, crop rotation and the forbidden usage of seed from the previous wheat crop are practised. These measures are very successful in Croatia.

### Pest control

Pest control in stored agriculture products is based on carrying out both preventive and curative measures—integrated stored-product protection. Table 2 summarises the protection measures undertaken in public and private sector houses. Hygiene protection measures are carried out more successfully in public sector store houses, less detailed and successfully in private sector store houses.

The most important measures are proper and timely store house preparation for reception of new products; store house cleaning; the removal of old product; the removal of old containers and unnecessary things; regular checks of the sanitary

state of the store house; store house treatment with insecticide and disinfectant; product control during the storage season; and quick intervention with appropriate measures if pests emerge.

Concern about stored products in Croatia has dated from 1960. Many control possibilities have been investigated (Ilic et al. 1969, 1973; Kalinovic, et al. 1981; Kalinovic 1984, 1985, 1986 b, 1993; Korunic 1990) and integrated into storage practice.

Except for the application of cooling and active seed ventilation by air circulation in silos and large floor store houses that have built-in apparatus, physical protection measures are limited. Pest control using atmosphere enriched with CO<sub>2</sub> is not carried out in practice, but intensive research is being done with the aim of its implementation (Hamel 1993). Stored-agricultural product protection by inert dusts is not carried out in our country, but research is being undertaken to find a domestic formulation and application (Korunic 1993; Maceljiski and Korunic 1972). Biological control measures in our store houses are not carried out, but the prospect of their implementation is good.

Chemical protection by pesticides is carried out in the integrated control of stored-product pests. In the Republic of Croatia there are 640 plant-protecting agents with 277 active ingredients. Of these 25 are stored-product protecting agents with nine active ingredients. Plant protection and product agents are manufactured in five chemical factories and there are also 60 branches of foreign firms.

In public sector storage facilities the following active ingredients are used:

- dichlorvos and pirimiphos-methyl for empty buildings, and for direct wheat and maize treatment by automatic apparatus;
- chlorpyrifos-methyl, deltamethrin and phosphine for direct grain, maize and oil plants treatment;

- malathion is used for empty building treatment (silos and large floor store houses), and methyl bromide and hydrogen cyanide for empty buildings (silos only).

In private facilities pesticides are seldom used; only 25% of private farmers treat their products or empty store houses. The following active ingredients are used:

- dichlorvos and pirimiphos-methyl are used for empty buildings;
- malathion is used in buildings and for wheat and corn kernel dusting.

Pesticides are not applied to corn cobs in wire baskets.

Phosphine, i.e. aluminium-phosphide in the form of tablets and pellets, and magnesium-phosphide (tablets, pellets, balls and plates), is used as the most efficient fumigant for harmful insects and mites in silos and large floor store houses.

Aluminium-phosphide has been used in Croatia since 1965, and magnesium-phosphide since 1975. Fumigation has been supplemented by fogging with insecticides such as dichlorvos and pirimiphos-methyl (Ilic et al. 1973; Kalinovic et al. 1979; Kalinovic 1985, 1986b). Phosphine preparations are used most in pest control in mills, flour store houses and in the tobacco industry (Kalinovic 1983).

Pest control in store houses is carried out by means of different applicators: liquid forms of insecticides by different spraying machines, atomising dampers and sprinklers made in Croatia or abroad; direct wheat treatment in silos and large floor store houses by special machines (Vobomatic etc.); and solid form phosphine fumigants by manual spear and automatic doser.

All pesticides are used under conditions of common standards, and according to manufacturers' and legal regulations of the Republic of Croatia.

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