

Stored product mites (Acari: Astigmata) infesting food in various types of packaging

Jan Hubert · Marta Nesvorna · Vlado Volek

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Abstract From 2008 to 2014, stored product mites have been reported from prepackaged dried food on the market in the Czech Republic. The infestation was by *Carpoglyphus lactis* (L.) in dried fruits and *Tyrophagus putrescentiae* (Schrank) in dog feed. The infestation is presumably caused by poor protection of the packages. We compared various packaging methods for their resistance to mites using dried apricots and dog feed in laboratory experiments. The trial packages included nine different plastic films, monofilm, duplex and triplex, and one type of plastic cup (ten replicates per packaging type). All packaging materials are available on the Czech market for dried food products. The samples of dried food were professionally packed in a factory and packaged dried apricots were exposed to *C. lactis* and dog food to *T. putrescentiae*. After 3 months of exposure, the infestation and mite density of the prepackaged food was assessed. Mites were found to infest six types of packages. Of the packaging types with mites, 1–5 samples were infested and the maximum abundance was 1,900 mites g⁻¹ of dried food. Mites entered the prepackaged food by faulty sealing. Inadequate sealing is suggested to be the major cause of the emerged infestation of dried food.

Keywords Dried food · Package · Storage · Mite infestation

Introduction

Stored product arthropods cause postharvest losses estimated from 9 to 20 % of stored commodities in the world (Phillips and Throne 2010). The packaging of products is the last

J. Hubert (✉) · M. Nesvorna
Biologically Active Substance in Crop Protection, Crop Research Institute, Drnovska 507, Praha 6
Ruzyně, Prague 16106, Czech Republic
e-mail: hubert@vurv.cz

V. Volek
Czech Packaging Institute SYBA, Prague, Czech Republic

line of defense for processors against insect infestation (Hou et al. 2004). Plastic materials have a passive function providing protection against external damage due to handling, blows, and attack by micro- and macro-organisms (Riudavets et al. 2007). It is well documented that consumers-size food packages vary considerably in their resistance to insects (Highland 1978; Newton 1988; Mullen 1994; Athanassiou et al. 2011). The current packaging films appear on the market with unknown protective effect to stored product pests, including mites.

Here, we compared the resistance of nine types of packaging films and one plastic cup against mites. We selected mite species based on our experience with recent infestation of dried food products appearing on the Czech market. Dried fruits were infested by *Carpoglyphus lactis* (L.) (Hubert et al. 2011) and dog food by *Tyrophagus putrescentiae* (Schrank) (Brazis et al. 2008; Gill et al. 2011). These pest mites are of serious medical importance. The contribution of *C. lactis* to allergen diseases is poorly known (Zheltikova et al. 1997) but *T. putrescentiae* is known to cause allergen sensitization of both urban and rural population (Rodriguez del Rio et al. 2012) as well as pet dogs (Mueller et al. 2005). Both mites can transfer mycotoxin-producing fungi to the prepackaged dried food (Canfield and Wrenn 2010; Hubert et al. 2014).

Materials and methods

The experimental design included 10 packaging types (nine films and one plastic cup, all $n = 10$; Table 1) and prepackaged dried apricots (K-servis Praha, Rudná u Prahy, Czechia) for *C. lactis* and dog food (Purina-Pro Plan, Nestlé, St. Louis, MO, USA) for *T. putrescentiae*. Before the experiment the food was checked using a dissection microscope STEMI 2000 (Carl Zeiss, Jena, Germany) for the presence of mites, and stored in the freezer ($-20\text{ }^{\circ}\text{C}$). Samples of $5 \pm 0.25\text{ g}$ were packed using a vertical form-fill-seal (FFS) packaging machine MH1 and a professional operator (ASTRO, Vlašim, Czechia). Sample no. 2 was an exception, as it was packed using an impulse sealer IZ 3B (Agrokomplet, Český Dub, Czechia), because this type of foil cannot be packed by an MH1 machine. The prepackaged foods were stored in the freezer prior to the experiment (approx. 24 h). The experiment was carried out in Lock&Lock plastic boxes ($180 \times 110 \times 110\text{ mm}$). The cups were tested separately because their size was not compatible with the other packages. One box always contained nine packages with different films placed vertically. Moistened filter paper on the bottom provided approximately 85 % relative air humidity.

Carpoglyphus lactis and *T. putrescentiae* originated from the rearing facilities of the Crop Research Institute (Prague, Czechia). The laboratory strain of *C. lactis* was collected in former Czechoslovakia in 1965 by E. Zdarkova, from figs in a food-processing factory. *Tyrophagus putrescentiae* was collected in a grain storage in Bustehrad (Czechia) in 1996. The mites were mass-reared in plastic chambers derived from IWAKI tissue cell cultures with filter cap plugs (P-Lab, Praha, Czechia). The chambers were kept in desiccators (P-Lab) with a saturated KCl solution providing 85 % r.h. and incubated at $25 \pm 1\text{ }^{\circ}\text{C}$ in the dark. The mites were reared on diet composed of dog food, wheat germ, Aqua-tropic dried fish food, Pangamin (dried brewer's yeast, *Sacharomyces cerevisiae*; Rapeto, Bezdruzice, Czechia) and gelatin (10:10:3:2:1 wt ratio). The diets were ground, sieved on an AS 200 sieving machine (Retsch, Haan, Germany), and heated to $70\text{ }^{\circ}\text{C}$ for 30 min. The rearing cultures were 1 month old before the experiment.

Mites were removed from the rearing chambers using a paint brush and a dissection microscope, and 500 ± 50 individuals of unknown sex were transferred to plastic vials

Table 1 Mite infestation of food packages. ‘Inf.’ indicates the numbers of infested samples out of 10 replicates, ‘N’ the number of mites found. The numbers in brackets indicate dead mites

No.	Description-composition	Thickness (μm)	<i>Carpoglyphus lactis</i>		<i>Tyrophagus putrescentiae</i>	
			Inf.	N	Inf.	N
1	Film (mono) PP transparent, printed	40	1	9,000	2	2,840; 5,170
2	Film (mono) PE white, unprinted	40	0		5	18; 256; 675; 1,480; (1)
3	Film (duplex) PP/PP, unprinted	20/30	1	30 (312)	2	27; (1)
4	Film (duplex) PP/PP cast, unprinted	25/25	0		0	
5	Film (duplex) PET/PE white, unprinted	12/70	0		0	
6	Film (triplex) petmet/AL/PE, unprinted	12/9/60	0		1	(1)
7	Film (triplex) PET/petmet/PE, unprinted	12/12/40	0		1	2
8	Film (duplex) PP/PP, printed	30/20	0		0	
9	Film (duplex) PP/ppmet, printed	30/20	2	1; (2)	0	
10	Plastic PP + IML cup, snap-on plastic PP lid	500 ^a /450 ^b	0		0	

AL aluminum foil, PP polypropylene, PE polyethylene, PET polyethylene terephthalate, met metalized, IML in-mould-label

^a Wall thickness, ^b lid thickness

(10 ml) with 0.5 ± 0.05 g dried apricot or dog feed. One vial with mites was added to each plastic box, it was placed on the bottom in the center of the box (see Fig. 1a). The boxes were kept in darkness at 25 ± 1 °C and the experiment lasted 3 months. In all boxes, the mites could freely move around in the boxes and on the packages. The sequence of the nine packages within a box was the same in all ten replicates. At the end of the experiment all



Fig. 1 **a** An experimental box with nine packages and a vial with the mites (arrow). BCDE—examples of package infestation by stored product mites and the entrances to the packages; **b** inadequate sealing of polyethylene foil (Table 1, no. 2) and *T. putrescentiae* invader; **c** detail of infested dried dog food from the package in **b**; **d** faulty sealing of polypropylene film package (Table 1, no. 1) and *C. lactis* invading; **e** detail of infested dried apricot from the package in **d**

packages were opened and checked for mite infestation under the STEMI 2000 dissection microscope. If mites were found, the packages were inspected for holes or faulty sealing.

Results

Mites were found in six types of packages (Table 1). The numbers of infested samples were from 1 to 5 per packaging type. Most infested samples were found in the ‘mono’ packages, consisting of one layer of film (nos. 1 + 2): mites were found in 8 of the 40 samples (= 20 %). No difference was found in infestation percentage between packages with two (duplex; nos. 3–5, 8 and 9) and three (triplex; nos. 6 + 7) layers of film: mites were found in 5 of 100, and in 2 of 40 samples, respectively; both 5 %. No infestation was found in the plastic cups (Table 1).

The number of infested mites per package ranged from 1 to 9,000 individuals. Some individuals were found dead. The mites did not make holes in packages but entered through a faulty seal. Inadequate seals were found in all samples with mite infestation by visual observation under dissection microscope (Fig. 1).

Discussion

Stored product mites are small—idiosoma length is 380–400 µm for *C. lactis*, 280–350 µm for *T. putrescentiae* (Hughes 1976)—allowing them to enter food packages through minuscule openings created by faulty seals. For the recent infestation of dried-fruit packages in the Czech hypermarkets, the possibility that mite infestation originated before packaging of the products cannot be excluded completely (Cobanoglu 2009; Hubert et al. 2011). However, the observed ability to infest packages indicated that cross-infestation during storage of prepackaged products is possible, especially when the products are stored in sufficiently humid warehouses. In the experiment, some packages may have been sealed wrongly, whereas some may have been damaged during manipulation.

Apart from faulty sealing, mites may enter prepackaged dried food via holes made by insect penetrators (e.g., the grain borer *Rhyzopertha dominica*; Coleoptera: Bostrichidae) (Nesvorna, pers. obs.), which increase the risk of multi-infestation. The invasion of food package during their storage may bring mites into consumers’ houses (Thind and Clarke 2001). Industries should therefore develop mechanisms for thorough inspection of packaged dried fruits and dog feed prior to release of the products on to the market.

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