+

EGYPTIAN ACADEMIC JOURNAL OF

BIOLOGICAL SCIENCES ZOOLOGY

B

ISSN 2090-0759

WWW.EAJBS.EG.NET

Vol. 13 No. 2 (2021)

.

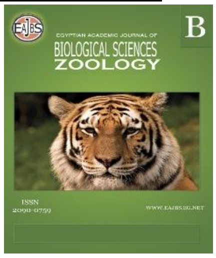
www.eajbs.eg.net

Citation: *Egypt. Acad. J. Biolog. Sci. (B. Zoology) Vol. 13(2) pp: 339-351(2021)*

DOI: 10.21608/EAJBSZ.2021.235863

Egypt. Acad. J. Biolog. Sci., 13(2): 339-351(2021)

Egyptian Academic Journal of Biological Sciences
B. Zoology
ISSN: 2090 – 0759
http://eajbsz.journals.ekb.eg/



The Suitability of Some Storage Products to *Tyrophagus putrescentiae* and *Sancassania berlesei* Infestation Accompanied with Application Some Flavoring Powders to Reduce Population

EL-Sayed, M. Mostafa
Plant Protection Department, Faculty of Agriculture, Zagazig University, Egypt
E.mail*: AMIbrhiem@agri.zu.edu.eg

ARTICLE INFO
Article History
Received:18/10/2021
Accepted:25/12/2021

Keywords:
Tyrophagus putrescentiae, *Sancassania berlesei*, population growth, dry milk, bran, flour, rice, curcuma, black pepper, basil, mint.

ABSTRACT

The storage mites *Tyrophagus putrescentiae* and *Sancassania berlesei* are the most important pests of stored foods (dry milk, bran, flour, rice, wheat, corn, oats, etc.) and are found in heavy infestation. The main objective of the present study work was to determine the population growth of *T. putrescentiae* and *S. berlesei* on different storage products i.e. dry milk, bran, flour (wheat and maize), and rice after 15 and 30 days of infestation. The developmental stages which were studied, were the eggs, larvae, nymphs, and adults for the former species, in addition to the hypopial stage for the second species. The results showed that the lowest numbers of all developmental stages for the two mite species were recorded on rice, followed by maize flour, wheat flour and bran while on the dry milk the highest numbers of all developmental stages were stated during 15 and 30 days. The number of hypopial stage was increased gradually on dry milk, bran, wheat flour, maize flour, and rice after 15 & 30 days, respectively.To decrease the two tested mites, flavoring powders (mint, basil, black pepper and curcuma) were mixed with target store products with a monitoring population of different developmental stages. Curcuma powder caused a 60-80% reduction with Curcuma on the five stored products for *T. putrescentiae* after 15 days and a 40-50% reduction after 30 days. Concerning the *S. berlesei,* Curcuma caused a reduction of more than 70% after 15 days and 40 % after 30 days. The other flavoring powders caused lower reductions than Curcuma, the arrangement of these powders descending were black pepper, basil and mint, respectively. From these results, we can use these powders to decrease the numbers of studied stored mites *T.putrescentiae* and *S. berlesei* on the target stored products to decrease their population subsequently damage.

INTRODUCTION

Foods, fibers, fuels, and raw materials are the four major categories of agricultural products. Cereals (grains), vegetables, fruits, oils, meat, milk, eggs, and fungi are all food classes. Not all agricultural food is directly consumed fresh. Rather, it is processed by drying, preservation, or manufacturing in one of its stages, and then stored until it is transferred to the place or time of consumption. Postharvest losses from stored-product insects have been reported to range from 9% in wealthy countries to 20%

Citation: *Egypt. Acad. J. Biolog. Sci. (B. Zoology) Vol. 13(2) pp: 339-351(2021)*
DOI: 10.21608/EAJBSZ.2021.235863

or more in impoverished countries (Phillips and Throne, 2010). In addition to insects, several other organisms attack stored products. These include microorganisms (mainly fungi and bacteria, which cause infection and deterioration), mites, rodents, and birds (Chomchalow, 2003). Insects and mites are regular inhabitants and accidental food invaders, but mites have probably been associated with stored food for as long as food has been stored. Mites occur widely in a variety of stored products so stored food materials harbored a large assemblage of mite species (Li *et al.,* 2015). Mite species showed a high adaptation to such environments would have found it an easy step to invade larger, manmade food stores.

The acaridia comprises an extremely large number of species belonging to several families including those of the superfamily Acaroidea (Robertson, 1959). The acaridid mite species are expected to be found in all types of habitats including the stored and food materials (Akimov and Oksentyuk, 2018).

The biological activities of the acaridid species adversely affect the stored grain and food products as some the damage the cereal germs and the flour (Afifi and Hafez, 1988; Arvind *et al.,* 2015; Chai QiAng *et al.,* 2020; Manoj *et al.,* 2020; Seiedy *et al.,* 2009; Vogel *et al.,* 2021). Other acaridid species infest milk, cheese bran, dried fruits, rice, foodstuff, oilseed products and food commodities (Aygun *et al.,* 2007; Ballal *et al.,* 2021; Chmielewski, 1999; Guo Wei *et al.,* 2015; Hasegawa, 1975; Moriya, 1975; Pankiewicz-Nowicka *et al.,* 1984; Silva *et al.,* 2018)

The presence of arthropods in durable goods can have both direct and indirect health consequences on humans. Contamination of food with arthropod pieces and associated pollutants, which can be allergic or even carcinogenic, is the most prevalent direct result. The most important indirect consequence is that their presence might alter the storage microenvironment, making long-lasting items more conducive to fungus and other microbes' rapid development. Some of these fungi can create poisons that are harmful to humans (for example, aflatoxins). Arthropods may contribute to the transmission of microbes, increasing product contamination, and they may host bacteria that have developed antibiotic resistance, contributing to the spread of antibiotic resistance in food. Several species may also host, attract, or transmit tapeworms, predators, or parasitoids that can be harmful to people's health his domestic animals. Many acarid species are capable of infesting moistened or previously infested grains and seeds where they destroy the germ rendering it unfit for planting or significantly reducing their nutritive values and germination power. Attack flour gives a bitter taste to the bread after baking also infestation of mite products reduces the nutritional value of the product as a result of consuming a large amount of contaminated food products food (Erban *et al.,* 2021; Hubert *et al.,* 2018, 2006; Michalczyk-Wetula *et al.,* 2021; Musk *et al.,* 1989; Sánchez-Borges *et al.,* 1997; Valbuza *et al.,* 2020)

The two acarid mites *Tyrophagus putrescentiae* (Schrank) and *Sancassania berlesei* (Michael)(Acari: Acaridae) are exposed to occur in all of the habitats including the stored grains, flour, bran, powder milk, food and other commodities (Kopecky *et al.,* 2013; Mostafa, 2011; Osman *et al.,* 2016). Some investigations were carried out to decrease the population growth of certain acarid mites by using some plant materials (Dales, 1996; Gulati, 2007; Gulati and Mathur, 1995; Valbuza *et al.,* 2020; Watanabe *et al.,* 1989).

The purpose of this study is to investigate the suitability of dry milk, bran, wheat, flour, maize flour, and rice for *T. putrescentiae* and *S. berlesei* infestation by enumeration of different developmental stages during different observation periods. Also, a study of the effect of some flavorings powder such as mint, basil, black pepper, curcuma aromatic substances in reducing the number of different moving developmental stages of the examined mites infested target stored products. To test a hypothesis control role of the tested flavorings powder in mite management in target stored products.

MATERIALS AND METHODS

Stored Materials Preparations:

Dry milk, bran, flour (wheat and maize) and rice were packaged to insulate from moisture and subjected to freezing in deep freeze (-20 °C) to kill any living insects or arthropods and their eggs, as well as the aspiration to remove mature insects or arthropods from the line. As well as the powder of leaves of basil (*Ocimum basilicum* L.; Lamiaceae) and mint (*Mentha viridis* L.; Lamiaceae). Besides, the seeds of black pepper (*Piper nigrum* L.; Piperaceae) and rhizomes of turmeric (*Curcuma longa* L., Zingiberaceae) were prepared by air drying the parts of selected plants then manually crushed and sieved to exclude the fine powder. The dry powders were subjected to sterilization with the freezing treatment.

Mites Rearing:

The two acarid mites, *Tyrophagus putrescentiae* (Schrank) and *Sancassania berlesei* (Michael)(Acari: Acaridae) were initially obtained from contaminated wheat flour collected from local storage (El-sharqia Governorate) and morphologically characterized to guarantee species identity. In the laboratory, mites were placed into a tiny glass jar and reared on a culture medium consisting of flour and dried yeast under room conditions at 27 ± 2 °C, 70% RH, and LD 11: 13 h (Thind and Dunn, 2002). Mites that had entered the last quiescent stage (resting tritonymph) were arbitrarily selected and put into a Petri plate to obtain adult mites of known age. Following that, newly emerged adults (0- 24 hours old) were easily procured and used in the tests. Because sexual dimorphism exists in adult *T. putrescentiae* and *S. berlesei*, sexing was done using secondary sexual features (Hughes, 1976)

Stored Products Host Preference and their effect on Mites' Population Growth:

A small cylindrical transparent plastic tin (3×3 cm) was firmly enclosed with the upper lid, while the bottom was covered to a depth of about 1 cm with a mixture of plaster of Paris/charcoal (9: 1 ratio) to prevent moisture condensation on the lid and sides. One gram of each food material was placed in each cell then five fertile females of two mite species *Tyrophagus putrescentiae* and *Sancassania berlesei* were separately transferred by camel brush. The cells were examined daily to provide with few drops of water for maintaining suitable moisture content. The cells were kept in the laboratory for a period of one month. The investigation was carried out twice, the former after 15 and 30 days of infestation. Each food material was replicated 5 times for each investigation. The temperature was recorded daily and relative humidity reached 28±3 °C and 80±5 % R.H.

Concerning the powdered materials of leaves of basil and mint besides, the seeds of black pepper and rhizomes were used to decrease the population growth of two mite species. Coarse powder of the above mentioned mixed uniformly with each of five food materials including dry milk, bran, wheat flour, maize flour and rice using a spatula to prepare a concentration of 1% (W/W). Five replicates of all materials were used.Numbers of eggs, larvae, nymphal stages and adults were counted for the first mite species. These stages in addition to hypopi were calculated for *Sancassania berlesei.*

Mite Examinations:

The mites were analyzed by flotation technique. In brief, the dust and flour samples were mixed with a saturated salt solution, followed by separation by centrifugation. After aspiration onto filter paper, the mites were counted under a stereomicroscope.

Statistical Analysis:

The experiments were laid out in a complete randomized design. The obtained data were subjected to a one-way analysis of variance and separated by Duncan's multiple range test at the 5% level in different treatments which was performed using the Statistix statistical software 8.1.

RESULTS AND DISCUSSION

Population Growth of *Tyrophagus putrescentiae* on Different Storage Products Through 15 And 30 Days:

Table (1) shows that after 15 days all developmental storages reached to maximum on dry milk which averaged 43.4, 24.40, 54.4 and 24.6 for eggs, larvae, nymphs, and adults, respectively. The biological activities of two acarid mites *Tyrophagus putrescentiae* and *Sancassania berlesei* adversely affected the stored products. (Pankiewicz-Nowicka and Boczek, 1984) examined several natural products of which powdered milk as the food of *Tyrophagus putrescentiae*. They cleared that attractiveness was related to the combination of at least 2 groups of other biologically active compounds.

The visiting pest in milk powder in the kitchen. It was cleared the predominant one was the mite *Tyrophagus putrescentiae* which was most abundant in August-October (Moriya, 1975). *T. putrescentiae* was found in 10.9% and appeared to be the most important mite species (Hasegawa, 1975).Where the minimum means were 12.6, 11.2, 32.8 and 6.8 for the above-mentioned developmental stages, respectively on rice.

Tyrophagus putrescentiae between the major pests in the rice samples. This species was predominant and appeared after 26 weeks on rice stored at low temperatures(Yao MeChi *et al.,* 2009).

The infestation of stored grains/seeds by Acarina species in the Endirne province of Turkey was assessed. The most prevalent pest was *Acarus siro* (31.03%) followed by *Lepidoglyphus destructor* (24.14%) and *Tyrophagus putrescentiae* (12.07%). The infestation was highest in stored wheat (39.65%) followed by sunflower seed (31.03%) and rice (8.62%)(Cobanoglu, 1996).

The infestations reached 100 % in rough rice with mites in Taiwan (Tseng, 1981).While, bran means occupied the second rank recorded with 37.8, 20.6, 48.0 and 19.0 individuals for the same developmental stages.The effect of bran moisture content and initial population density on the mass production of *T. putrescentiae* was studied. They found that population growth grew to a maximum (over 50,000 mites/g bran) (Li YaYing *et al.,* 2015).

Protein and saccharides were the two most important nutrients of artificial diets. *Tyrophagus putrescentiae* population increased by 319, 317 and 180 times within six weeks, when yeast powder, glucose, or sugar was added to the basic wheat bran diet (Huang He *et al.,* 2013).

Tyrophagus putrescentiae which in turn could be maintained on a wheat bran medium (Ballal *et al.,* 2021).

On wheat and maize flour, means were recorded at 33.6 &28.6 eggs, 17.2&15.0 larvae, 43.6&38.6 nymphs and 14.4 &11.8 adults. *Tyrophagus putrescentiae* was statistically more on wheat flour (1742.73 eggs, 2517.73 mites/100 g flour) (Arvind *et al.,* 2015).Egg, larval, protonymphal and deutonymphal stages of *Tyrophagus putrescentiae* that fed on *Triticum aestiveum* flour had faster development compared to those fed on *Z. mays* and *G. max*. fecundity of *Tyrophagus putrescentiae* was higher (23.8) in *T. aestiveum* than in other diets (Sarwar *et al.*, 2010).

Tyrophagus putrescentiae was found infesting flour of maize and wheat that was being used for the rearing of *Corcyra cephalonica* in the laboratory in India(Lal *et al.,* 1973).The infestation with mites on rice grains was 10.7 % when *T. putrescentiae* was reared on various commodities, the growth rate was highest on powdered animal feed, followed in order of descending suitability by wheat flour, maize flour, barley, rice flour, pulse flour, powdered fennel and powdered coriander (Maurya *et al.,* 1982).

After 30days, all numbers for the same developmental stages increase clearly. The highest number of eggs was 102.2 eggs on dry milk which was significantly different from other means on bran, wheat flour, maize flour and rice which reached 35 eggs on it. The same trend was noticed with larvae which averaged 118.2 larvae on dry milk which was significantly different from other values 103.0 larvae on the bran, 94.8 on wheat flour, 85.2 larvae on maize flour and 62.6 larvae on rice. The nymphs reached 218.0 individuals on dry milk which was significantly different from other values 197.2 nymphs on the bran, 187.0 on wheat flour, 168.0 nymphs on maize flour and an average of 148.0 nymphs on rice. Concerning the adult stage, the highest number was 133.8 adults for dry milk which is significantly different from other means and recorded 104.6 adults for bran, 93.4 adults for wheat flour, 81.6 adults for maize flour and 58.0 adults for rice as shown in Table (1).

Table 1 The number of different developmental stages *Tyrophagus putrescentiae* in different storage products at different examination periods.

Products	Examination period							
	15 days				30 days			
	Eggs	Larvae	Nymphs	Adults	Eggs	Larvae	Nymphs	Adults
Dry milk	43.40[a]	24.40[a]	54.40[a]	24.60[a]	102.20[a]	118.20[a]	218.00[a]	133.80[a]
Bran	37.80[b]	20.60[b]	48.00[b]	19.00[b]	84.60[b]	103.00[b]	197.20[b]	104.60[b]
Wheat flour	33.60[c]	17.20[c]	43.60[c]	14.40[c]	68.40[c]	94.80[c]	187.00[c]	93.40[c]
Maize flour	28.60[d]	15.00[d]	38.60[d]	11.80[d]	61.60[d]	85.20[d]	168.00[d]	81.60[d]
Rice	12.60[e]	11.20[e]	32.80[e]	6.80[e]	35.00[e]	62.60[e]	148.00[e]	58.00[e]

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test, Reported numbers represent the means of 5 replicates.

Population Growth of *Sancassania berlesei* on Different Storage Products Through 15 And 30 Days:

The general trend of the developmental stages of *Sancassania berlesei* i.e., eggs, larvae, nymphs and adults in the same way as the developmental stages of *Tyrophagus putrescentiae* after 15 and 30 days in Table (2) which shows the highest mean of eggs recorded on dry milk 87.8& 261.8 eggs after 15 &30days, respectively. Following that the number of eggs on bran reached 82.4&244.6 eggs after 15 and 30 days.

Eight species of mites were identified from 75 wheat bran samples mainly including *Caloglyphus berlesei* (40.7 %) and *Tyrophagus putrescentiae* (33.3%). The breeding densities of mites in bulk, package and bucket storage were 0.50, 0.25 and 0.3 mite/g, respectively (Guo Wei *et al.,* 2015).

On wheat flour, the eggs averaged 76.6 & 229.6 eggs after 15 & 30 days respectively. The eggs recorded on maize flour were 70.4 & 218.2 eggs after 15 & 30days, respectively. The lowest mean numbers of eggs were 54.4 & 189.8 eggs on rice. For the larval stage, the means recorded were 37.2, 31.8, 25.4, 19.8 and 15.2 individuals on dry milk, bran, wheat flour, maize flour and rice after 15 days. But after 30 days, the mean number of larvae was 162.0, 140.0, 132.8, 122.2 and 102.0 individuals on dry milk, bran, wheat flour, maize flour and rice, respectively.

Concerning the nymphal stage, the mean numbers were 74.2& 357.2 nymphs on dry milk after 15 & 30 days, respectively. On bran, these numbers were 66.2 & 269.2 nymphs after 15 & 30 days, respectively. The mean number of nymphs was 59.2 & 258.8 nymphs on wheat flour after 15 & 30 days respectively. But on maize flour, the means of nymphs were 53.2& 243.6 nymphs after 15 & 30 days, respectively.The least numbers of nymphs recorded on rice reached 234.8 & 209.2 nymphs after 15 & 30 days, respectively. The mean numbers of adults were 298.0 & 797.8 adults on dry milk after 15 & 30 days, respectively. While these means reached 283.0 & 648.4 adults on bran after 15 & 30 days, respectively. On wheat flour, these means were 274.2 & 529.0 adults after 15 & 30 days, respectively. The mean numbers of adults were 264.4 & 413.0 adults on maize flour after 15 & 30 days, respectively. The lowest mean numbers of adults were 234.8 & 320.0 individuals after 15 & 30 days, respectively (Table 2).

Regarding the hypopial stage, there is no hypopi formed on dry milk after 15 & 30 days, while the lowest means of hypopi recorded on bran reached 2.4 & 13.4 hypopi after 15 & 30 days, followed by wheat flour which averaged 6.6 & 44.0 hypopi after 15 & 30 days, respectively. The hypopial mean numbers reached 9.8 & 74.0 hypopi on maize flour after 15 & 30 days, respectively. The highest mean number of hypopial stages were recorded with rice and reached 14.6 & 142.2 hypopi after 15 & 30 days, respectively as shown in Table (2).

Table 2 The number of different developmental stages *Sancassania berlesei* in different storage products at different examination periods.

Products	Examination period									
	15 days					30 days				
	Eggs	Larvae	Nymphs	Adults	Hypopus	Eggs	Larvae	Nymphs	Adults	Hypopus
Dry milk	87.80[a]	37.20[a]	74.20[a]	298.00[a]	0.00[e]	261.80[a]	162.00[a]	297.20[a]	797.80[a]	0.00[e]
Bran	82.40[b]	31.80[b]	66.20[b]	283.00[b]	2.40[d]	244.60[b]	140.00[b]	269.20[b]	648.40[b]	13.40[d]
Wheat flour	76.60[c]	25.40[c]	59.20[c]	274.20[c]	6.60[c]	229.60[c]	132.80[c]	258.80[b]	529.00[c]	44.00[c]
Maize flour	70.40[d]	19.80[d]	53.20[d]	264.40[d]	9.80[b]	218.20[d]	122.20[d]	243.60[b]	413.00[d]	74.00[b]
Rice	54.40[e]	15.20[e]	48.40[e]	234.80[e]	14.60[a]	189.80[e]	102.00[e]	209.20[b]	320.00[e]	142.20[a]

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test, Reported numbers represent the means of 5 replicates.

Effect of Some Flavoring's Powders on Different Developmental Stages of *Tyrophagus Putrescentiae* Infested Stored Products:

Effect of mint: Mint was decreased in the numbers of all stages after 15 days and 30 days on infested stored products dry milk, bran, wheat flour, maize flour and rice. After 15 days, the lowest number of eggs was 10.6 eggs on rice while, the highest number with dry milk was 34.8 eggs. But larvae were 19.2 individuals on dry milk and rice, this number was 7.0 individuals. The numbers of nymphs were 44.8 nymphs on dry milk and 25.2 nymphs on rice. For adults, the highest number with dry milk was 16.2 adults and the lowest number was 4.2 adults on rice. After 30 days, the highest numbers of eggs, larvae, nymphs and adults were 19.8, 107.2, 200 and 119.6 individuals, respectively on dry milk. While the lowest numbers on rice were 29.8, 57.2, 136.4 and 48.4 individuals, respectively for the observed developmental stages as shown in Table (3).

The varying concentrations of powdered leaves of *Encalyptus* and *Mentha* and rhizomes of curcuma in controlling *T. putrescentiae* in wheat flour. The rhizomes of curcuma were effective even at a concentration of 0.1%, reducing the mean egg-laying to 7.66 eggs per female in wheat flour. They ascertained that curcuma rhizomes were the most promising for possible use against *T. putrescentiae* (Gulati and Mathur, 1995).

Effect of basil: The highest numbers of all developmental stages of *T.s putrescentiae* were recorded with dry milk followed by bran, wheat flour, maize flour, while the lowest number was stated with rice after 15 and 30 days Table (3).

Effect of black pepper: The reduction of all numbers of different developmental stages was higher than with mint and basil. The lowest numbers were recorded on rice after 15 and 30 days. While the highest numbers of all developmental stages on dry milk (Table 3).

Effect of curcuma: The greatest effect on the decrease of numbers due to curcuma. The lowest numbers of eggs were 6.8& 23.4 eggs after 15 & 30 days respectively on rice. For the larvae 2.8 & 26.6 larvae after 15 & 30 days, respectively on rice. While the lowest number of nymphs was 11.2 & 123.0 nymphs after 15 & 30 days, respectively on rice. Concerning the adult stage, the numbers were 1.0 & 34.0 individuals after 15 & 30 days, respectively on rice (Table 3).

Turmeric (*Curcuma longa* L.) is acaricidal against *T. putrescentiae* and *Suidasia nesbitti* in stored wheat. It was noticed that at a 0.1 % level of curcuma oil-treated wheat grains showed a reduction of 54.8 *T. putrescentiae* and 70.2 *S. nesbitti* followed by curcuma powder (72.2 and 79 mites) as compared to untreated wheat (125.2 and 144.2, respectively). A more pronounced inhibitory effect was found on eggs and larvae than on nymphs and adults. The largest reduction was in curcuma oil-treated grains where only 18.2, 21.8 % eggs of *T. putrescentiae* and *S. nesbitti* survived at 0.1% concentration as against 85.4 and 84.8% eggs, respectively in untreated grains. Among the mite species, *T. putrescentiae* was more susceptible to curcuma treatments than *S. nesbitti*. Curcuma oil was most effective followed by powder and oleoresin. After 45 days of treatment curcuma oil, powder and oleoresin provided 95.5, 93.1 and 78.55 relative protection in the case of *T. putrescentiae* and 96.1, 94.0 and 72.1 % in the case of *S. nesbitti* (Gulati, 2007).

Table 3 Effect of some flavoring powders on different developmental stages of *Tyrophagus putrescentiae* infested stored products.

Control tools	Products	Examination period							
		15 days				30 days			
		Eggs	Larvae	Nymphs	Adults	Eggs	Larvae	Nymphs	Adults
Mint	Dry milk	34.80^{a}	19.20^{a}	44.80^{a}	16.20^{a}	91.80^{a}	107.20^{a}	200.00^{a}	119.60^{a}
	Bran	31.80^{b}	14.80^{b}	35.20^{b}	9.00^{b}	76.40^{b}	86.80^{b}	185.00^{b}	90.20^{b}
	Wheat flour	24.20^{c}	13.40^{c}	31.20^{c}	7.20^{c}	66.60^{c}	82.60^{c}	178.80^{c}	79.80^{c}
	Maize flour	20.80^{d}	11.20^{d}	30.20^{c}	6.40^{c}	56.80^{d}	77.80^{d}	160.20^{d}	71.20^{d}
	Rice	10.60^{e}	7.00^{e}	25.20^{d}	4.20^{d}	29.80^{e}	57.20^{e}	136.40^{e}	48.40^{e}
Basil	Dry milk	31.80^{a}	16.20^{a}	42.40^{a}	11.40^{a}	88.60^{a}	97.00^{a}	194.00^{a}	101.20^{a}
	Bran	26.80^{b}	12.20^{b}	29.40^{b}	7.20^{b}	71.40^{b}	75.40^{b}	174.00^{b}	79.40^{b}
	Wheat flour	21.20^{c}	10.80^{c}	25.20^{c}	5.80^{bc}	61.20^{c}	71.40^{c}	164.40^{c}	69.80^{c}
	Maize flour	17.40^{d}	9.40^{d}	23.80^{d}	6.20^{c}	53.00^{d}	63.80^{d}	150.20^{d}	60.80^{d}
	Rice	9.80^{e}	5.40^{e}	20.60^{e}	3.60^{d}	28.00^{e}	45.00^{e}	125.40^{e}	39.80^{e}
Black pepper	Dry milk	24.80^{a}	13.20^{a}	33.40^{a}	8.00^{a}	77.40^{a}	84.00^{a}	178.20^{a}	83.40^{a}
	Bran	23.20^{b}	8.60^{b}	24.80^{b}	5.20^{b}	58.40^{b}	63.60^{b}	164.40^{b}	69.20^{b}
	Wheat flour	16.80^{c}	7.80^{b}	19.80^{c}	4.40^{b}	51.20^{c}	59.20^{c}	153.80^{c}	58.60^{c}
	Maize flour	13.80^{d}	6.40^{c}	18.60^{c}	5.60^{c}	45.20^{d}	47.80^{d}	139.60^{d}	51.40^{d}
	Rice	8.20^{e}	3.20^{d}	13.40^{d}	2.40^{d}	24.20^{e}	36.60^{e}	109.20^{e}	28.60^{e}
Curcuma	Dry milk	15.00^{a}	9.40^{a}	23.40^{a}	5.20^{a}	55.00^{a}	63.40^{a}	167.40^{a}	65.40^{a}
	Bran	11.80^{b}	6.40^{b}	16.40^{b}	2.40^{b}	44.20^{b}	33.60^{b}	150.80^{b}	52.80^{b}
	Wheat flour	8.80^{c}	4.20^{c}	13.40^{c}	1.40^{c}	32.60^{c}	31.20^{c}	139.40^{c}	43.00^{c}
	Maize flour	6.80^{d}	2.80^{d}	11.20^{d}	1.00^{c}	23.40^{d}	26.60^{d}	123.00^{d}	34.00^{d}
	Rice	3.60^{e}	1.40^{e}	6.80^{e}	0.60^{c}	17.80^{e}	18.80^{e}	84.80^{e}	18.80^{e}

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test, Reported numbers represent the means of 5 replicates.

Effect Of Some Flavoring Powders On Different Developmental Stages of *Sancassania berlesei* Infested Stored Products:

Effect of mint: The highest numbers of eggs, larvae, nymphs and adults recorded with dry milk after 15 & 30 days were significantly different from other stored products, i.e., bran, wheat flour, maize flour and rice which were recorded with it the lowest numbers of all developmental stage as shown in Table (4).

Effect of basil: The trend of basil resembles mint but the recorded numbers of all stages of *S. berlesei* developmental stages were lower than these numbers recorded with mint after 15 & 30 days on different infested stored products. The highest numbers were noticed with dry milk and the lowest numbers were on rice as shown in Table (4).

Effect of black pepper: The reduction of all developmental stage numbers of mite ***S. berlesei*** was greater than mint and basil. The lowest numbers of all stages were recorded with rice after 15 & days for eggs, larvae, nymphs and adults. While the highest numbers stated on dry milk after 15 & 30 days for the developmental stages as shown in Table (4).

Effect of curcuma: The lowest numbers for all flavoring's powders recorded with curcuma on rice after 15 & 30 days for all developmental stages 12.2 & 77.2 eggs, 1.4 & 28.0 larvae, 9.0 & 117.0 nymphs and 9.4 & 104.0 adults, respectively (Table4).

Effect of Some Flavoring Powders on Hypopial Stage of *Sancassania berlesei*:

The hypopial stage did not form on dry milk after 15 days with mint, basil and black pepper (Table 4), while the hypopial state was 0.40 on dry milk with curcuma. The numbers of hypopi increased gradually on bran, wheat flour, maize flour and rice after 15 days. After 30 days, the numbers of hypopi increased for dry milk, bran, wheat flour, maize flour and rice with mint, basil, black pepper and curcuma, respectively (Table 4).

Table 4 Effect of some flavoring powders on different developmental stages of *Sancassania berlesei* infested stored products**.**

Control tools	Products	Examination period									
		15 days					30 days				
		Eggs	Larvae	Nymphs	Adults	Hypopi	Eggs	Larvae	Nymphs	Adults	Hypopi
Mint	Dry milk	71.60[a]	29.60[a]	60.00[a]	179.80[a]	0.00[e]	238.00[a]	138.00[a]	265.80[a]	709.40[a]	1.80[e]
	Bran	61.60[b]	23.20[b]	45.40[b]	156.40[b]	10.40[d]	209.00[b]	122.60[b]	245.40[b]	536.00[b]	27.60[d]
	Wheat flour	53.80[c]	17.80[c]	38.20[c]	142.20[c]	17.80[c]	199.80[c]	114.20[c]	238.00[c]	461.80[c]	52.40[c]
	Maize flour	43.80[d]	14.80[d]	34.20[d]	131.20[d]	25.20[b]	196.60[d]	108.00[d]	224.40[d]	350.40[d]	85.60[b]
	Rice	38.80[e]	9.40[e]	28.80[e]	120.00[e]	36.20[a]	159.80[e]	84.40[e]	188.80[e]	265.00[e]	161.20[a]
Basil	Dry milk	63.60[a]	24.20[a]	54.20[a]	154.00[a]	0.00[e]	231.60[a]	127.00[a]	255.60[a]	595.20[a]	5.00[e]
	Bran	53.20[b]	19.60[b]	36.80[b]	114.00[b]	15.00[c]	190.40[c]	104.20[b]	233.40[b]	473.60[b]	32.60[d]
	Wheat flour	47.40[c]	14.40[c]	28.80[c]	102.80[c]	26.00[d]	193.60[b]	97.00[c]	227.00[c]	407.80[c]	61.60[c]
	Maize flour	39.80[d]	12.80[d]	29.00[c]	97.00[d]	37.20[b]	190.40[c]	89.40[d]	208.40[d]	310.00[d]	94.00[b]
	Rice	34.40[e]	5.60[e]	24.20[d]	85.40[e]	47.60[a]	149.60[d]	70.80[e]	174.20[e]	212.20[e]	173.60[a]
Black pepper	Dry milk	50.40[a]	18.40[a]	43.80[a]	105.80[a]	0.00[e]	203.60[a]	108.80[a]	239.80[a]	502.80[a]	9.60[e]
	Bran	43.20[b]	14.00[b]	31.20[b]	84.60[b]	24.00[c]	148.40[c]	84.00[b]	218.60[b]	414.40[b]	43.00[d]
	Wheat flour	38.80[c]	11.80[c]	24.20[c]	72.20[c]	34.00[d]	140.40[d]	77.40[c]	208.00[c]	351.20[c]	73.40[c]
	Maize flour	33.40[d]	9.40[d]	19.80[d]	62.80[d]	47.40[b]	157.40[b]	70.60[d]	194.80[d]	261.20[d]	104.40[b]
	Rice	27.40[e]	4.00[e]	15.00[e]	53.40[e]	58.00[a]	129.60[e]	57.60[e]	149.00[e]	161.20[e]	188.40[a]
Curcuma	Dry milk	29.80[a]	14.60[a]	30.20[a]	70.40[a]	0.40[e]	138.00[a]	82.20[a]	223.80[a]	377.40[a]	18.40[e]
	Bran	22.20[b]	8.40[b]	23.00[b]	26.40[b]	32.80[c]	119.20[b]	47.40[b]	199.80[b]	309.00[b]	54.20[d]
	Wheat flour	15.40[c]	5.00[c]	18.00[c]	20.40[c]	45.60[d]	100.40[c]	41.00[c]	187.60[c]	252.20[c]	84.00[c]
	Maize flour	15.20[c]	4.20[c]	14.20[d]	15.80[d]	60.80[b]	85.40[d]	37.40[d]	169.80[d]	179.00[d]	115.20[b]
	Rice	12.20[d]	1.40[d]	9.00[e]	9.40[e]	70.40[a]	77.20[e]	28.00[e]	117.00[e]	104.00[e]	197.00[a]

Different letters in the same column indicate significant differences ($P \leq 0.05$) according to Duncan`s multiple range test, Reported numbers represent the means of 5 replicates.

Reduction Percent Caused by Flavoring Powders of *Tyrophagus putrescentiae* and *Sancassania berlesei* Moving Stages After 15 & 30 Days on Five Stored Products:

Curcuma powder caused a 63.25-82.68 % reduction of moving stages, black pepper 47.20- 62.60 % reduction, basil caused a 32.30- 44.41% reduction and mint caused a 22.44- 32.88% reduction after 15 days. While after 30 days, these percentages decreased to 36.98- 54.43 % reduction for curcuma, 26.47- 35.07% reduction for black pepper, 16.55- 21.74 % reduction for basil and 7.65-10.57 % reduction for mint on *T. putrescentiae* (Fig. 1).

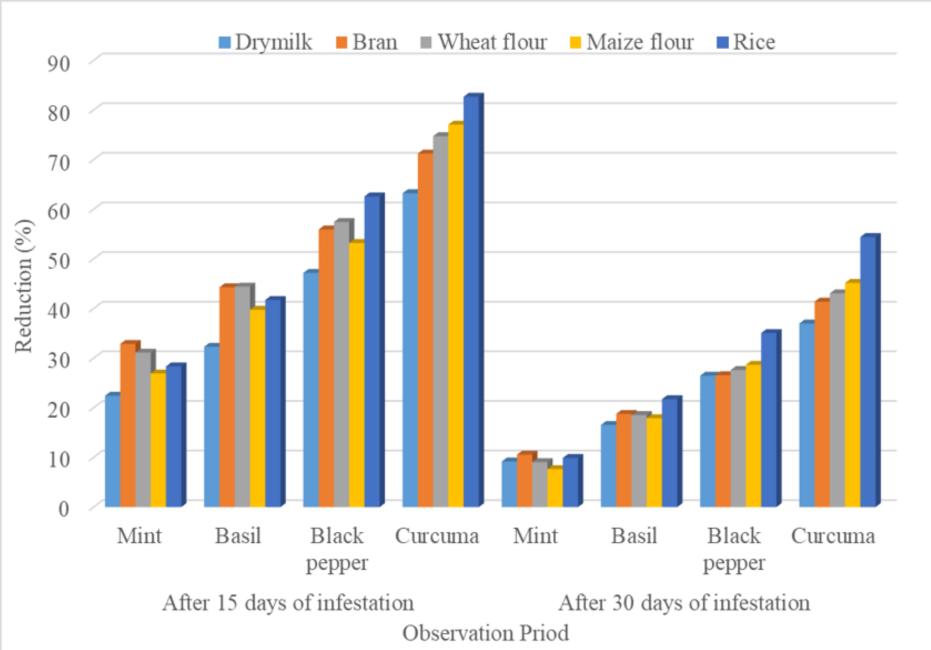


Fig. 1: Reduction percent caused by mint, basil, black pepper and curcuma of *Tyrophagus putrescentiae* moving stages after 15 & 30 days on tested five stored products.

Reduction percent between 71.18-76.47 % for curcuma, 58.34-61.03% for black pepper, 43.23-52.93% bail and 34.20-40.89 % mint after 15 days. These percent decreased to 41.21-46.71 for curcuma, 26.01-34.62 % for black pepper and 17.71-25.38 % for basil and 9.62-15.34for mint after 30 days on *S. berlesei* (Fig. 2).

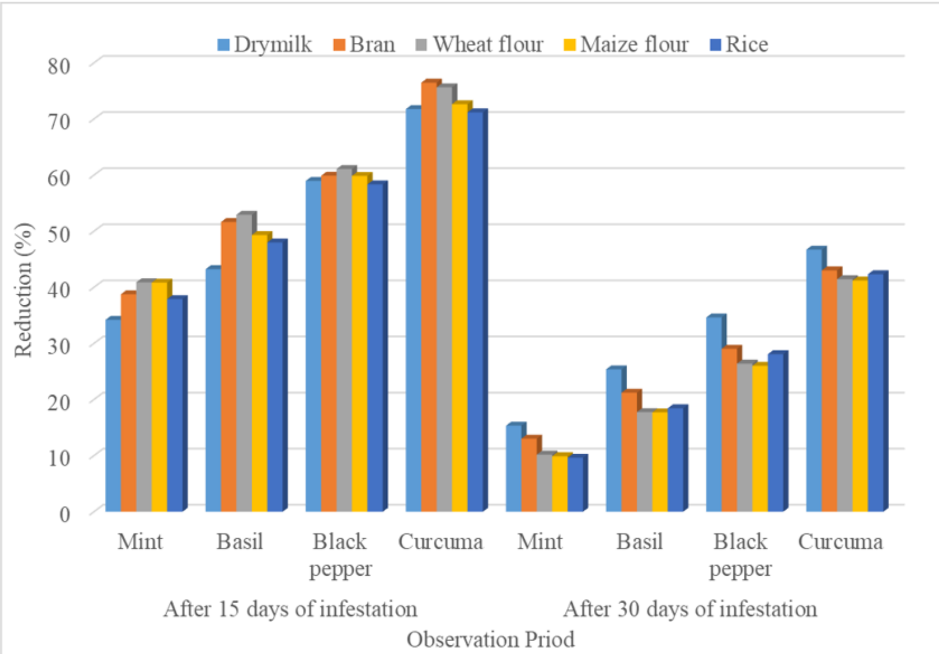


Fig. 2: Reduction percent caused by mint, basil, black pepper and curcuma of *Sancassania berlesei* moving stages after 15 & 30 days on tested five stored products.

Conclusion

Based on the results obtained from the current study, it can be ascertained that the suitability of dry milk, bran, wheat flour, maize flour and rice arranged in descending order for infestation with *Tyrophagus putrescentiae* and *Sancassania berlesei*. Also using the flavoring powders could be relatively effective e.g., curcuma, black pepper, basil and mint downwardly arranged based on the reduction of mite populations during storage so we could recommend applying the surpassed acaricidal flavoring powders on packages of stored products to minimize mite population in store.

REFERENCES

Afifi, F.A., Hafez, S.M., 1988. Effect of different plant extracts on the toxicity and behavior of *Tyrophagus putrescentiae* Schrank (Acari: Acaridae). *Annals of Agricultural Science (Cairo),* 33, 1375–1385.

Akimov, I.A., Oksentyuk, Y., 2018. Functional and ecological adaptations of several acaridid mite species (Acariformes, Astigmata) for feeding on stored produce. *Vestnik Zoologii,* 52, 323–330.

Arvind, Rachna Gulati, Anita, 2015. Comparative susceptibility and weight loss of wheat grains and flour due to *Tyrophagus putrescentiae* (Schrank). *Annals of Plant Protection Sciences,* 23, 246–249.

Aygun, O., Yaman, M., Durmaz, H., 2007. A survey on occurrence of *Tyrophagus putrescentiae* (Acari: Acaridae) in Surk, a traditional Turkish dairy product. *Journal of Food Engineering,* 78, 878–881. https://doi.org/10.1016/ j.jfoodeng. .11.029

Ballal, C.R., Gupta, S.K., Tripti Gupta, Richa Varshney, 2021. A simple protocol for rearing a native predatory mite *Neoseiulus indicus*. *Current Science*, 120, 1923–1926. https://doi.org/10.18520/cs/v120/i12/1923-1926

Chai QiAng, Jiang Feng, Li ChaoPin, 2020. Preliminary investigation of acaroid mite breeding in flour contaminated with dust in Hong Kong, China. *Zhongguo Bingyuan Shengwuxue Zazhi / Journal of Pathogen Biology*, 15, 322–323.

Chmielewski, W., 1999. Acceptance of buckwheat grain as a food by *Tyrophagus putrescentiae* (Schr.) (Acari: Acaridae). *Fagopyrum*, 16, 95–97.

Chomchalow, N., 2003. Protection of stored products with special reference to Thailand. *Assumption University Journal of Technology*, 7, 31–47.

Cobanoglu, S., 1996. Determination, distribution and hosts of Acarina group harmful and useful on stored products in the province of Edirne. *Turkiye Entomoloji Dergisi*, 20, 199–210.

Dales, M.J., 1996. A Review of Plant Materials Used For Controlling Insect Pests Of Stored Products. Natural Resources Institute.

Erban, T., Klimov, P.B., Harant, K., Talacko, P., Nesvorna, M., Hubert, J., 2021. Label-free proteomic analysis reveals differentially expressed Wolbachia proteins in *Tyrophagus putrescentiae*: mite allergens and markers reflecting population-related proteome differences. *Journal of Proteomics*, 249. https://doi.org/10.1016/j.jprot.2021.104356

Gulati, R., 2007. Potential of garlic as grain protectants against *Tyrophagus putrescentiae* Schrank and *Suidasia nesbitti* Hughes in Wheat. *Systematic and Applied Acarology*, 12, 19–25.

Gulati, R., Mathur, S., 1995. Effect of Eucalyptus and Mentha leaves and Curcuma rhizomes on *Tyrophagus putrescentiae* (Schrank) (Acarina: Acaridae) in wheat.

Experimental & Applied Acarology, 19, 511–518. https://doi.org/10.1007/BF00052919

Guo Wei, Zhan XiaoDong, Zhao JinHong, Huang YueE, Li ChaoPin, 2015. Preliminary study on effects of different storage methods on mite breeding in wheat bran. Zhongguo Meijie Shengwuxue ji Kongzhi Zazhi = Chinese Journal of Vector Biology and Control, 26, 81–83.

Hasegawa, M., 1975. Survey on insects and mites found in milk powder traps. *Journal of the Food Hygienic Society of Japan,* 16, 29–34.

Huang He, Xu XueNong, Lv JiaLe, Li GuiTing, Wang EnDong, Gao YuLin, 2013. Impact of proteins and saccharides on mass production of *Tyrophagus putrescentiae* (Acari: Acaridae) and its predator *Neoseiulus barkeri* (Acari: Phytoseiidae). Biocontrol Science and Technology, 23, 1231–1244. https://doi.org/10.1080/09583157.2013.822849

Hubert, J., Nemcova, M., Aspaly, G., Stejskal, V., 2006. The toxicity of bean flour (*Phaseolus vulgaris*) to stored-product mites (Acari: Acaridida*). Plant Protection Science-Prague,* 42, 125.

Hubert, J., Stejskal, V., Athanassiou, C.G., Throne, J.E., 2018. Health Hazards Associated with Arthropod Infestation of Stored Products. *Annual Review of Entomology*, 63, 553–573. https://doi.org/10.1146/annurev-ento-020117-043218

Hughes, A.M., 1976. The Mites of Stored Food and Houses. H.M. Stationery Office.

Kopecky, J., Perotti, M.A., Nesvorna, M., Erban, T., Hubert, J., 2013. Cardinium endosymbionts are widespread in synanthropic mite species (Acari: Astigmata). *Journal of invertebrate pathology,* 112, 20–23.

Lal, L., Katiyar, O.P., Singh, J., Mukharji, S.P., 1973. A new host of *Tyrophagus putrescentiae* (Schrank) (Tyroglyphidae: Acarina) at Varanasi. *Bulletin of Grain Technology,* 11, 68–69.

Li, C., Zhan, X., Sun, E., Zhao, J., Wang, H., He, J., Wang, J., 2015. The density and species of mite breeding in the stored products in China. *Nutrición Hospitalaria,* 31, 798–807.

Li YaYing, Zhang Yan, Hu Qin, Liu Lei, Xu XueNong, Liu Huai, Wang JinJun, 2015. Effect of bran moisture content and initial population density on mass production of *Tyrophagus putrescentiae* (Schrank) (Acari: Acaridae). *Systematic and Applied Acarology,* 20, 497–506.

Manoj, Rachna Gulati, Komal Duhan, 2020. Effect of *Tyrophagus putrescentiae* (Acari: Acaridae) infestation on biochemistry of pearl millet grain/flour. *Agricultural Research Journal,* 57, 266–269. https://doi.org/10.5958/2395-146X.2020.00040.X

Maurya, K.R., Jamil, Z., Dev, B., 1982. Mite-infestation-pattern in various stored products in Lucknow. *Biological Memoirs,* 7, 116–120.

Michalczyk-Wetula, D., Jakubowska, M., Felska, M., Skarzynski, D., Makol, J., Plonka, P.M., 2021. *Tyrophagus putrescentiae* (Sarcoptiformes: Acaridae) in the *in vitro* cultures of slime molds (Mycetozoa): accident, contamination, or interaction? *Experimental and Applied Acarology,* 84, 445–458. https://doi.org/10.1007/s10493-021-00608-4

Moriya, K., 1975. A survey of visiting pests in milk powder at the kitchen. *Journal of the Food Hygienic Society of Japan,* 16, 59–61.

Mostafa, E.M., 2011. Incidence of mites inhabiting stored onion bulbs in Egypt, with description of a new species of the genus *Lasioseius* Berlese (Acari: Gamasina). *Journal of Plant Protection and Pathology,* 2, 855–863.

Musk, A.W., Venables, K.M., Crook, B., Nunn, A.J., Hawkins, R., Crook, G.D.W., Graneek, B.J., Tee, R.D., Farrer, N., Johnson, D.A., Gordon, D.J., Darbyshire, J.H., Newman Taylor, A.J., 1989. Respiratory symptoms, lung function, and sensitisation to flour in a British bakery. *British Journal of Industrial Medicine,* 46, 636–642.

Osman, M.A., Khairy, D.M., Mostafa, F.A., 2016. Food as paramount factor on the biology and life table of *Tyrophagus putrescentiae* (Schmnk)(Astigmata: Acaridae). *Acarines: Journal of the Egyptian Society of Acarology,* 10, 19–23.

Pankiewicz-Nowicka, D., Boczek, J., 1984. Comparison of food preference of some acarid mites (Acarida: Acaroidea). Acarology VI / editors, D.A. Griffiths and C.E. Bowman.

Pankiewicz-Nowicka, D., Boczek, J., Davis, R., 1984. Food selection in *Tyrophagus putrescentiae* (Schrank) (Acarina: Acaridae). *Journal of the Georgia Entomological Society,* 19, 317–321.

Phillips, T.W., Throne, J.E., 2010. Biorational approaches to managing stored-product insects. *Annual Review of Entomology,* 55, 375–397.

Robertson, P.L., 1959. A revision of the genus *Tyrophagus*, with a discussion on its taxonomic position in the Acarina. *Australian Journal of Zoology,* 7, 146–182.

Sánchez-Borges, M., Capriles-Hulett, A., Capriles-Behrens, E., Fernández-Caldas, E., 1997. A new triad: sensitivity to aspirin, allergic rhinitis, and severe allergic reaction to ingested aeroallergens. *Cutis,* 59, 311–314.

Sarwar, M., Xu XueNong, Wu KongMing, 2010. Effects of different flours on the biology of the prey *Tyrophagus putrescentiae* (Schrank) (Acarina: Acaridae) and the predator *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Acari: Phytoseiidae). *International Journal of Acarology,* 36, 363–369. https://doi.org/10.1080/01647954.2010.517563

Seiedy, M., Saboori, A., Kamali, K., Pakdel, A.K., 2009. Mites (Acari) found in flour mills in the Karaj region of Iran. *Systematic and Applied Acarology,* 14, 191–196.

Silva, G.L. da, Esswein, I.Z., Radaelli, T.F. de S., Rocha, M.S., Ferla, N.J., Silva, O.S. da, 2018. Influence of various diets on development, life table parameters and choice oviposition test of *Tyrophagus putrescentiae* (Acari: Acaridae): an illustration using scanning electron microscopy (SEM). *Journal of Stored Products Research,* 76, 77–84. https://doi.org/10.1016/j.jspr.2018.01.006

Thind, B.B., Dunn, J.A., 2002. A laboratory evaluation of a regulated airflow through wheat at four combinations of temperature and humidity on the productivity of three species of stored product mites. *Experimental and Applied Acarology,* 27, 89–102. https://doi.org/10.1023/a:1021522321940

Tseng, Y.H., 1981. Ecological notes on mites infesting stored products in Taiwan. *Journal of the Agricultural Association of China,* 48–57.

Valbuza, M.F., Matioli, A.L., Sato, M.E., Potenza, M.R., Campos, A.E.C., 2020. Mites in spice and medicinal dehydrated plants stored in bulk in the metropolitan area of Sao Paulo. *Journal of Stored Products Research,* 85, 101540.

Vogel, P., Silva, G.L. da, Esswein, I.Z., Dallazen, M.C., Heidrich, D., Pagani, D.M., Hoehne, L., Scroferneker, M.L., Valente, P., Ferla, N.J., 2021. Effects of infestations of the storage mite *Tyrophagus putrescentiae* (Acaridae) on the presence of fungal species and mycotoxin production in stored products. *Journal of Stored Products Research, 94*. https://doi.org/10.1016/j.jspr.2021.101883

Watanabe, F., Tadaki, S., Takaoka, M., Ishino, M., Morimoto, I., 1989. Killing activities of the volatiles emitted from essential oils for *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae* and *Tyrophagus putrescentiae*. *Shoyakugaku Zasshi = Japanese Journal of Pharmacognosy*, 43, 163–168.

Yao MeChi, Lee ChiYang, Lu KuangHui, 2009. Survey and monitoring of insect and mite pests in imported rice. *Journal of Taiwan Agricultural Research*, 58, 17–30.

ARABIC SUMMARY

ملائمة بعض المواد المخزونة للإصابة بحلم *Tyrophagus putrescentiae* و*Sancassania berlesei* مصحوبا باستخدام بعض مساحيق التوابل لتقليل التعداد

السيد محمود مصطفى
قسم وقاية النبات - كلية الزراعة - جامعة الزقازيق - مصر

يعتبر حلم المواد المخزونة *Tyrophagus putrescentiae* و*Sancassania berlesei* من أهم آفات المواد الغذائية المخزونة (كاللبن الجاف، الردة، الدقيق، الأرز، القمح، الذرة، الشوفان....إلخ) حيث وجدوا بإصابات كثيفة لذا كان الغرض من هذا العمل تحديد نمو التعداد لكلا نوعي الحلم على مختلف المواد المخزونة مثل اللبن الجاف والردة ودقيق القمح والذرة والارز بعد 15 و30 يوما من الإصابة. وشملت أطوار دورة الحياة المدروسة البيض واليرقات والحوريات والاطوار البالغة لكلا نوعي الحلم، بالإضافة الى الطور الرحال لنوع الحلم الثاني. وأوضحت النتائج وجود أقل تعداد لكل الأطوار لنوعي الحلم المدروسين على الأرز متبوعا بدقيق الذرة ثم القمح والردة، بينما سجلت أعلى الاعداد على اللبن الجاف لكل الاطوار خلال 15 و30 يوما من الإصابة. كما ازدادت اعداد الطور الرحال بالتدريج على اللبن الجاف والرده بعد 15 و30 يوما على الترتيب. وبغرض تقليل تأثيرات نوعي الحلم المدروس على المواد المخزونة تم دراسة تأثير خلط بعض مساحيق التوابل (النعناع والريحان والفلفل الاسود والكركم) على الأطوار المختلفة للحلم بعد 15 و30 يوما، حيث تسبب الكركم في خفض التعداد من 60 الى 80% عند استخدام الكركم على انواع المواد المخزونة المدروسة للحلم الاول بعد 15 يوما، كما نتجت 40 - 50 % خفض بعد 30 يوما لنفس نوع الحلم المدروس، اما بخصوص نوع الحلم الثاني فقد تسبب الكركم بنسبة حفض أكثر من 70% بعد 15 يوما وأكثر من 40 % بعد 30 يوما. في حين سببت باقي المساحيق المستخدمة نسبه خفض أقل من الكركم وكان ترتيبها التنازلي الفلفل الاسود يليه الريحان ثم النعناع، ومن خلال النتائج المتحصل عليها يمكن القول بانه يمكن استخدام هذه المساحيق لتقليل تعداد كلا نوعي الحلم على المواد المخزونة لتقليل اثار هذه الانواع من الأكاروسات.