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EFFICACY OF SIX CROATIAN INERT DUSTS AND DIATOMACEOUS EARTH CELATOM MN-51® AGAINST RED FLOUR BEETLE *TRIBOLIUM CASTANEUM* HERBST (COLEOPTERA: TENEBRIONIDAE) ON WHEAT

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ABSTRACT

The study investigated the insecticidal efficacy of six Croatian inert dusts (D-01, JU-1, MA-4, MR-10, OP-4 and PD-1) and diatomaceous earth Celatom Mn-51® against red flour beetle Tribolium castaneum *Herbst on wheat. The influence of mentioned dusts on the offspring development has also been investigated. The experiment was carried out in laboratory conditions on insects aged 7-21 days. Doses of 600 and 700 mg kg^{-1} were tested for JU-1, MR-10, OP-4 and PD-1 and 300 and 400 mg kg^{-1} for D-01, MA-4 and Celatom Mn-51® alongside previously mentioned doses (600 and 700 mg kg^{-1}). The* *mortality rate of red flour beetle was determined on the 7th and 14th day of exposure and progeny was determined by number of developed adults. Regarding the insecticidal efficacy on* T. castaneum *the tested inert dusts can be divided into three groups: very effective dusts (D-01 (LD_{90} = 600 mg kg^{-1}), MA-4 (LD_{90} = 500 mg kg^{-1})), medium-effective dusts (JU-1 and PD-1) and low-efficient dusts (OP-4 and MR-10). Based on the obtained results it can be concluded that there are some resources of inert dusts with high insecticidal potential in the Republic of Croatia.*

Key words: Tribolium castaneum, *insecticidal effect, progeny inhibition, Celatom Mn-51®*

1. INTRODUCTION

Agricultural products need to be adequately stored after harvesting to prevent loss of quality and quantity (Rajashekar *et al.*, 2012). For the protection of stored products preventive and curative measures are applied in the storage: preventive measures include all measures that prevent the appearance of storage pests, while curative measures include the suppression of existing harmful organisms in storage. In practice, chemical insecticides (fumigants) are most often used. Chemical insecticides are very effective (Sakka and Athanassiou, 2021), but they have a number of negative consequences: frequent use and inadequately implemented fumigation measures lead to the development of resistant populations of insects (Collins 2010; Nayak *et al.*, 2020); pollution of the environment (Aktar *et al.*, 2009); harmful effect on non-target organisms (Ducom, 2012); and the presence of residues calls into question the healthiness of the treated products (Eddleston, 2000). Due to the emergence of increasing pest resistance to grain protectants (Subramanyam and Hagstrum, 1995) and the need to reduce insecticide residues in stored products, there is an increasing emphasis on testing and developing new insecticides that would be non-toxic to warm-blooded organisms, and would serve as a substitute for conventional insecticides in the protection of grain products (Arthur, 1996; Paponja *et al.*, 2021). Inert dusts are natural substances used to protect stored grain products from harmful insects. The advantage of inert dusts is that they provide a long-term protection, they are easy to apply, maintain grain quality and have low toxicity for warm-blooded organisms (Korunić, 2013). Diatomaceous earth (DE) is the most widely used inert dust and a promising alternative to the use of traditional chemical insecticides (Korunić *et al.*, 2020; Baliota and Athanassiou, 2023). DE is of natural origin (Floros *et al.*, 2018), it consists of fossilized skeletons or frustules of diatoms, unicellular algae of Eocene and Miocene age (Korunić *et al.*, 2016). Fields and Korunić (2002) state that during feeding and migration through the treated seed or treated surface, insects accumulate particles of inert dust that stick to the cuticle. The particles of inert dusts damage the waxy layer of the cuticle, leading to insect desiccation (Nikpay, 2006) and this is considered the main mode of action for silica-based inert dusts. Another form of effectiveness is cuticle abrasion as an additional mode of action. Cuticle abrasion is the main mode of action of other inert dusts (Fields and Korunić, 2002). Zeni *et al.* (2021) illustrated the insecticidal potential of DEs against a variety of insect taxa such as Blattodea, Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera. The red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) is a major secondary pest of wheat (Zilli *et al.*, 2022). The aim of this work was to test the insecticidal efficiency of Croatian inert dusts and their influence on the development of the offspring of the red flour beetle.

2. MATERIALS AND METHODS

For research purposes F1 generation of adult *T. castaneum* test insects was used. The breeding of test insects was carried out under controlled conditions at a temperature of 29±1°C, a relative humidity of 70-80% in the dark (Liu and Ho, 1999; Menon *et al*., 2001). A combination of hard wheat flour and dry yeast in a ratio of 10:1 was used for the insects growing medium (Abdelgaleil *et al*., 2009). Randomly chosen mixed sex adults, aged 7-21 days, were used in the research. Six Croatian inert dusts from five different locations were used: MR-10 from Martinovići (Banovina); OP-4 from Opatovac (Slavonia); JU-1 from Jurjevčani; MA-4 from Markuševec; PD-1 and D-01 from Podsusedsko dolje (Medvednica–Žumberak–Hrvatsko zagorje) and diatomaceous earth Celatom Mn-51® as an inert dust with high insecticidal activity (Korunić *et al*., 2017). Inert powder samples were ground in a Retsch PM 100® mill. After that, they were manually sifted through a 45 µm sieve, which resulted in uniform particle sizes of inert dust. The inert dusts were applied to glass containers with a volume of 200 ml filled with 100 g of sterile wheat with 3% grain breakage (Lucić, 2018). The glass containers were hermetically sealed and the contents were manually shaken for 60 s. After that, 50 adults of both sexes were introduced per treatment, including the control treatment. Then the glass containers were covered with perforated lids and stored in controlled conditions (29±1°C; 70-80% RH). Inert dusts were applied in the following doses: 300, 400, 600 and 700 mg kg^{-1}. Doses of 600 and 700 mg kg^{-1} were tested for JU-1, MR-10, OP-4 and PD-1 and 300 and 400 mg kg^{-1} for D-01, MA-4 and Celatom Mn-51® alongside previously mentioned doses (600 and 700 mg kg^{-1}) (Lucić, 2018). A control treatment (treatment without the application of dust) was also set up. Mortality readings were performed after two exposures: 7 and 14 days, and after 14 days all insects were removed from the wheat, and the wheat with laid eggs was placed in controlled conditions (29±1°C; 70-80% RH) for monitoring the number of developed offspring (F1 generation). The number of developed offspring was determined on the 63rd day after setting up the experiment (when the adult stage emerged). Experiments for all treatments were set up in a completely randomized design with four replications (Lucić, 2018). Statistical processing of the collected data was carried out in SAS/STAT Software 9.4 (2022-2023). The results for all treatments were statistically processed by ANOVA analysis of variance, and the statistical significance of the differences was determined by the LSD test at the 0.05 probability level. The mortality of the tested insects is expressed as a percentage and shown in time series (days). Offspring are represented by the number of developed adults. Determined statistically significant differences among all treatments were tested with Tukey's Studentized Range (HSD) test at the 0.05 probability level. Data obtained from each dose response bioassay were subjected to probit analysis and LD_{50} and LD_{90} values and their 95% confidence intervals were estimated using IBM SPSS Statistics (IBM Corp. Released, 2013).

3. RESULTS AND DISCUSSION

The results of the tested inert dusts on wheat indicate a different insecticidal effect on the mortality of *T. castaneum* adults depending on the treatment, dose and exposure, and on the percentage of inhibition of offspring development depending on the dose (Table 1; Table 2).

In the treatment with inert dust D-01, a statistically significant difference compared to the control treatment was achieved at a dose of 600 mg kg^{-1} and an exposure of 7 days with a mortality of 57.5%, while increasing the dose to 700 mg kg^{-1}, a significant increase in mortality (94.5%) was recorded. By prolonging the exposure to 14 days, statistically significant higher mortality compared to the exposure of 7 days was achieved at doses of 400 and 600 mg kg^{-1}. At the exposure of 14 days, a statistically significant higher mortality (79.0%) compared to the control treatment and to the lowest dose (300 mg kg^{-1}) was achieved at the dose of 400 mg kg^{-1}, while increasing the dose to 700 mg kg^{-1} no statistically significant difference was noticed. Statistically significant offspring inhibition (86.92%) was achieved even at the lowest dose. By increasing the dose, inhibition of offspring increased, and complete inhibition was achieved at a dose of 600 mg kg^{-1}.

In the treatment with the inert dust MA-4 at the exposure of 7 days, statistically significant higher mortality (26.0%) compared to the control treatment and at the lowest dose (300 mg kg^{-1}) was achieved at the dose of 400 mg kg^{-1}. By increasing the dose to 600 mg kg^{-1} and 700 mg kg^{-1}, statistically significantly higher mortality was achieved (81.0% and 91.0 %, respectively). By prolonging the exposure to 14 days, a statistically significant higher mortality was achieved at all doses. After 14 days of exposure, a statistically significant difference compared to the control treatment was achieved at the lowest dose. Increasing the dose to 400 mg kg^{-1} resulted in a significant increase in mortality (75.5%), while further dose increase did not result in statistically significant higher mortality. Statistically significant inhibition of offspring (66.43%) was achieved even at the lowest dose. By increasing the dose to 400 mg kg^{-1}, the inhibition was statistically significant (90.84%), while at the highest dose (700 mg kg^{-1}) complete inhibition of the offspring was achieved.

In the treatment with the inert dust Celatom Mn-51®, after 7 days of exposure, a statistically significant higher mortality (32.0%) compared to the control treatment and to the lowest dose (300 mg kg^{-1}) was achieved at a dose of 400 mg kg^{-1}. Increasing the dose to 600 mg kg^{-1} resulted in a statistically significant higher mortality (87.5%), while further increasing the dose did not significantly change mortality. By extending the exposure to 14 days, statistically significant higher mortality was achieved at all doses, except for the highest dose (700 mg kg^{-1}). Maximum mortality (100.0%) was achieved after 14 days and at the highest dose (700 mg kg^{-1}). Statistically significant inhibition of offspring (77.33 %) was achieved at the lowest dose, while complete offspring inhibition was achieved at a dose of 600 mg kg^{-1}.

In the treatment with the inert dust JU-1 after 7 days of exposure, a statistically significant highest mortality (19.0%) was achieved compared to the control treatment, only at the highest dose (700 mg kg^{-1}). By prolonging the exposure to 14 days, a statistically significant higher mortality was achieved. At a dose of 700 mg kg^{-1}, a significantly higher mortality (68.0%) was achieved compared to the other doses, which is also the highest mortality achieved with the treatment of JU-1 dust. Statistically significant offspring inhibition (88.49%) was achieved even at the lowest dose (600 mg kg^{-1}).

In the treatment with inert dusts OP-4 and MR-10, at an exposure of 7 days, no statistically significant mortality was achieved compared to the control treatment and between applied doses. By prolonging the exposure to 14 days, a statistically significant mortality was achieved at the highest dose (700 mg kg^{-1}) with OP-4 in comparison to the control treatment, while treatment with MR-10 was not statistically different even after 14 exposure days. Despite the very low insecticidal effectiveness, a statistically significant offspring inhibition was recorded with dusts MR-10 (66.43%) and OP-4 (78.63%) at the dose of 600 mg kg^{-1}, respectively.

In the treatment with inert dust PD-1 at exposure of 7 days, a statistically significant higher mortality (19.5%) compared to the control treatment was achieved only at the highest dose (700 mg kg^{-1}). By prolonging the exposure to 14 days, statistically significant higher mortality (46.5%) compared to the control treatment was achieved at a dose of 600 mg kg^{-1}. Statistically significant offspring inhibition (82.12%) was achieved at the lowest dose (600 mg kg^{-1}).

Table 1. Insecticidal activity of inert dusts D-01, MA-4 and Celatom Mn-51® against *T. castaneum* after the 7th and 14th day of exposure on wheat, and the influence of inert dusts on progeny development

***Mortality rate* (%)±StD[1,2]**						**Number *of progeny* ±StD[3]**	***Inhibition* (%)**
Treatment	***Dose* (mg kg^{-1})**	**Exposition**		**F**	**P**		
		7th day	**14th day**				
D-01	0	0.0±0.00 cA	0.0±0.00 cA	0.00	<0.0000	114.7±18.30 a	-
	300	7.0±7.39 cA	27.0±23.64 bA	2.61	<0.1574	15.0±6.73 b	86.92
	400	25.5±3.41 cB	79.0±12.49 aA	68.28	<0.0002	2.5±1.73 b	97.82
	600	79.0±22.42 abB	99.5±1.00 aA	3.34	<0.1175	0.0±0.00 b	100.00
	700	94.5±3.41 aA	99.0±1.15 aA	6.23	<0.0468	0.0±0.00 b	100.00
	F	41.09	62.39			131.30	
	P	<0.0001	<0.0001			<0.0001	
	LD_{50}	486.26 mg kg^{-1} (456.43-515.39)	600 mg kg^{-1} = 99.5%				
	LD_{90}	655.25 mg kg^{-1} (614.33-716.03)	600 mg kg^{-1} = 99.5%				
MA-4	0	0.0±0.00 dA	0.0±0.00 bA	0.00	<0.0000	114.7±18.30 a	-
	300	0.5±1.00 dB	18.0±12.54 bA	7.74	<0.0319	38.5±17.61 b	66.43
	400	26.0±7.83 cB	75.5±26.65 aA	12.70	<0.0119	10.5±7.23 c	90.84
	600	81.0±8.72 abB	99.0±2.00 aA	16.20	<0.0069	1.5±1.91 c	98.69
	700	91.0±3.46 aB	99.0±1.15 aA	19.20	<0.0047	0.0±0.00 c	100.00
	F	80.90	54.80			69.41	
	P	<0.0001	<0.0001			<0.0001	
	LD_{50}	492.78 mg kg^{-1} (468.08-516.81)	500 mg kg^{-1} = 99.0%				
	LD_{90}	651.99 mg kg^{-1} (618.17-699.00)	500 mg kg^{-1} = 99.0%				

Celatom Mn-51®	0	0.0±0.00 cA	0.0±0.00 cA	0.00	<0.0000	114.7±18.30 a	-
	300	2.0±1.63 cB	21.5±13.40 cA	8.34	<0.0278	26.0±4.76 b	77.33
	400	32.0±22.86 bB	61.0±30.39 bA	2.33	<0.1781	6.7±3.20 c	94.15
	600	87.5±5.00 aB	99.5±1.00 aA	22.15	<0.0033	0.0±0.00 c	100.00
	700	97.0±3.46 aA	100.0±0.00 aA	3.00	<0.1340	0.0±0.00 c	100.00
	F	63.53	42.23			133.93	
	P	<0.0001	<0.0001			<0.0001	
	LD_{50}	456.03 mg kg^{-1} (426.18-483.92)	366.14 mg kg^{-1} (338.09-391.32)				
	LD_{90}	592.30 mg kg^{-1} (556.74-645.27)	462.35 mg kg^{-1} (431.22-517.05)				

[1] Mean values in the same column for each treatment marked with the same lower case letter are not significantly different (Tukey's HSD, P<0.05). (Lucić, 2018).
[2] Mean values in the same row for each dose marked with the same capital letter are not significantly different (Tukey's HSD, P<0.05). (Lucić, 2018).
[3] Mean values in the same column for each treatment marked with the same lower case letter are not significantly different (Tukey's HSD, P<0.05). (Lucić, 2018).

Source: (Lucić, 2018)

Table 2. Insecticidal activity of inert dusts JU-1, MR-10, OP-4 and PD-1 against *T. castaneum* after the 7th and 14th day of exposure on wheat, and the influence of inert dusts on progeny development

Mortality rate **(%)±StD**[1,2]						*Number of progeny* **±StD**[3]	*Inhibition* **(%)**
Treatment	*Dose* **(mg kg^{-1})**	**Exposition**		**F**	**P**		
		7th day	**14th day**				
JU-1	0	0.0±0.00 bA	0.0±0.00 cA	0.00	<0.0000	114.7±18.30 a	-
	600	8.5±3.41 abB	39.5±13.30 bA	5.39	<0.0593	13.2±7.45 b	88.49
	700	19.0±11.60 aA	68.0±4.32 aA	466.85	<0.0001	11.0±6.27 b	90.40
	F	5.95	28.80			67.56	
	P	<0.0100	<0.0001			<0.0001	
	LD_{50}	600 mg kg^{-1} = 19.0%	624.27 mg kg^{-1} (580.37-684.97)				
	LD_{90}	600 mg kg^{-1} = 19.0%	870.71 mg kg^{-1} (771.89-1175.78)				

MR-10	0	0.0±0.00 aA	0.0±0.00 aA	0.00	<0.0000	114.7±18.30 a	-
	600	2.5±1.91 aA	4.5±1.00 aA	3.43	<0.1135	38.5±27.92 b	66.43
	700	4.5±6.61 aA	9.0±10.52 aA	0.52	<0.4961	35.5±9.00 b	69.04
	F	0.96	1.92			12.23	
	P	<0.4411	<0.1798			<0.0006	
	LD_{50}	700 mg kg^{-1} = 4.5%	700 mg kg^{-1} = 9.0%				
	LD_{90}	700 mg kg^{-1} = 4.5%	700 mg kg^{-1} = 9.0%				
OP-4	0	0.0±0.00 aA	0.0±0.00 bA	0.00	<0.0000	114.7±18.30 a	-
	600	0.5±1.00 aA	0.5±1.00 abA	0.00	<1.0000	24.5±13.17 bc	78.63
	700	2.0±1.63 aA	3.0±2.58 aA	0.43	<0.5370	3.7±0.95 c	96.77
	F	3.91	4.30			56.18	
	P	<0.0369	<0.0280			<0.0001	
	LD_{50}	700 mg kg^{-1} = 2.0%	943.73 mg kg^{-1} (816.49-2725.56)				
	LD_{90}	700 mg kg^{-1} = 2.0%	1110.41 mg kg^{-1} (906.97-4005.08)				
PD-1	0	0.0±0.00 bA	0.0±0.00 bA	0.00	<0.0000	114.7±18.30 a	-
	600	3.5±2.51 bB	46.5±22.11 aA	14.93	<0.0083	20.5±5.74 b	82.12
	700	19.5±7.55 aB	42.5±8.39 aA	16.62	<0.0065	4.7±2.98 b	95.90
	F	12.69	13.92			42.31	
	P	<0.0005	<0.0003			<0.0001	
	LD_{50}	868.89 mg kg^{-1} (756.68-1838.69)	697.23 mg kg^{-1} (627.41-1349.79)				
	LD_{90}	1100.92 mg kg^{-1} (889.88-3035.43)	947.04 mg kg^{-1} (782.95-3444.72)				

[1] Mean values in the same column for each treatment marked with the same lower case letter are not significantly different (Tukey's HSD, P<0.05). (Lucić, 2018).

[2] Mean values in the same row for each dose marked with the same capital letter are not significantly different (Tukey's HSD, P<0.05). (Lucić, 2018).

[3] Mean values in the same column for each treatment marked with the same lower case letter are not significantly different (Tukey's HSD, P<0.05). (Lucić, 2018).

Source: (Lucić, 2018)

With regard to the insecticidal effect of the tested inert dusts on *T. castaneum*, the two most effective inert dusts of Croatian origin (D-01 and MA-4) can be singled out, along with diatomaceous earth Celatom Mn-51® with a high insecticidal effect: D-01 (LD_{90} = 600 mg kg^{-1}), MA- 4 (LD_{90} = 500 mg kg^{-1}) and Celatom Mn-51® (LD_{90} = 462.35 mg kg^{-1}). Particles of inert dust have an abrasive effect (Doumbia *et al.*, 2014), but the main mode of action is the absorption of cuticular lipids, which leads to cuticle damage (deterioration), resulting in desiccation and death of insects (Korunić, 1998; Subramanyam and Roesli, 2000). Particles adhere more easily to the rough cuticles of insects (Doumbia *et al.*, 2014). Shah and Khan (2014) reported that *T. castaneum* is the least susceptible to inert dusts compared to other cosmopolitan storage pests due to its smooth body on which inert dust particles are difficult to accumulate. Despite of that Athanassiou *et al.* (2021) stated that the powder achieves a knockdown effect on *T. castaneum*. The effectiveness of inert dust is manifested in direct contact with the target pest (Rigaux *et al.*, 2001). However, some researches indicate that insects can develop resistance to certain inert dusts, if they are constantly applied to the same population (Shah and Khan, 2014), but taking into account that inert dusts have a physical effect, resistance is ruled out on the basis of physiology (Rigaux *et al.*, 2001). Therefore resistance is attributed to the behavioral effect of insects that for certain reasons avoid contact with treated stored grain (Vayias *et al.*, 2008). Vardeman *et al.* (2007) stated that after losing water from the body, insects try to collect metabolic water through food and by directly ingesting water into the body. According to Doumbia *et al.* (2014) the cuticle of *T. castaneum* is thicker compared to insects from the genus *Sitophilus*, therefore the process of lipid absorption is slower. Some insect species are more or less susceptible to inert dusts because of their agility (Arthur *et al.* 2020). Baldassari *et al.* (2008) reported similar results, where according to the research they did not record maximum mortality of *Rhyzopertha dominica* (Fab.) and *T. castaneum* after 14 days of exposure to a dose of 500 mg kg^{-1} of Protector®. Athanassiou and Korunić (2007) recorded a maximum mortality of *R. dominica* after 14 days of exposure to a dose of 75 and 150 mg kg^{-1}. The reason for this is that the experiments were carried out at an elevated temperature of 30 °C. Increased temperature increases the mobility of insects (Fields and Korunić, 2000) which leads to greater respiration of insects and loss of water from the body (Subramanyam and Roesli, 2000). Various abiotic factors greatly influence the performance of inert dusts (Athanassiou *et al.*, 2014). Namely, an increase in the relative humidity of the air in the stored space and high stored products moisture reduce the insecticidal effect of inert dusts due to the absorption of moisture (Korunić, 1998; Fields and Korunić, 2000; Subramanyam and Roesli, 2000). In the conducted research, samples D-01, MA-4 and Celatom Mn-51® showed high inhibition of *T. castaneum* offspring at low doses (Lucić, 2018). The mentioned samples of Croatian inert dust also achieved high inhibition of the offspring of *Sitophilus oryzae* (L.) in the research by Liška *et al.* (2017). Subramanyam and Roesli (2000) believe that it is more important in practical terms to prevent the development of the offspring than to directly suppress the parents. Eroglu *et al.* (2019) state that some inert dust can vary in efficacy of progeny inhibition due to different temperature and relative humidity levels. Kljajić *et al.* (2010) tested different preparations based on DE and zeolite, and they concluded that almost twice the concentration of zeolite than DE is needed to control adult insects and prevent the offspring development. This is confirmed by the different composition of substances in DEs and zeolites: amorphous silicon dioxide is mainly represented in DEs (Golob, 1997; Korunić, 1998), while crystalline hydrated aluminosilicates are represented in zeolites (Sprynskyy *et al.*, 2005).

4. CONCLUSION

According to the results obtained in this research the insecticidal effectiveness of inert dusts of Croatian origin, they can be divided into three groups: highly effective dusts (D-01, MA-4) including Celatom Mn-51®; medium efficiency dusts (JU-1 and PD-1) and low efficiency dusts (OP-4 and MR-10). Considering the established high insecticidal efficiency of inert dusts of

Croatian origin (MA-4 and D-01), it can be concluded that there are resources of inert dusts in the Republic of Croatia with high efficiency potential that can be further researched and applied as part of integrated pest management (IPM).

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UČINKOVITOST ŠEST HRVATSKIH INERTNIH PRAŠIVA I DIJATOMEJSKE ZEMLJE CELATOM MN-51® U SUZBIJANJU KESTENJASTOG BRAŠNARA *TRIBOLIUM CASTANEUM* HERBST (COLEOPTERA: TENEBRIONIDAE) NA PŠENICI

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SAŽETAK

U radu je istražena insekticidna učinkovitost šest hrvatskih inertnih prašiva (D-01, JU-1, MA-4, MR-10, OP-4 i PD-1) i dijatomejske zemlje Celatom Mn-51® u suzbijanju kestenjastog brašnara Tribolium castaneum *Herbst na pšenici. Istraživan je i utjecaj navedenih prašina na razvoj potomstva. Pokus je proveden u laboratorijskim uvjetima s kukcima starosti 7-21 dan. Za tretmane JU-1, MR-10, OP-4 i PD-1 korištene su doze od 600 i 700 mg kg^{-1} a za tretmane D-01, MA-4 i Celatom Mn-51®, uz* *navedene, korištene su i doze od 300 i 400 mg kg^{-1}. Mortalitet kestenjastog brašnara utvrđen je nakon 7. i 14. dana ekspozicije, a potomstvo je utvrđeno brojem razvijenih odraslih jedinki. S obzirom na insekticidnu učinkovitost na* T. castaneum, *testirana inertna prašiva možemo podijeliti u tri skupine: vrlo učinkovita prašiva (D-01 (LD_{90} = 600 mg kg^{-1}), MA-4 (LD_{90} = 500 mg kg^{-1})), srednje učinkovita prašiva (JU-1 i PD-1) i nisko učinkovita prašiva (OP-4 i MR-10). Na temelju dobivenih rezultata može se zaključiti da u Republici Hrvatskoj postoje izvori inertnih prašina s visokim insekticidnim potencijalom.*

Ključne riječi: Tribolium castaneum, *insekticidni učinak, inhibicija potomstva, Celatom Mn-51®*