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Tribolium castaneum (Herbest) sensitivity toward three herbal insecticides Sirinol, Palizin and Tondexir

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Abstract
In this research, three herbal insecticides namely Sirinol, Palizin and Tondexir were evaluated for their efficacy in the control of *Tribolium castaneum* (Herbst), under laboratory conditions. The LC_{25} and LC_{50} values of Sirinol, Palizin and Tondexir were estimated on adult insect. Furthermore, LC_{25} and LC_{50} values for Sirinol, Palizin and Tondexir treatments on adult insect were 451, 262 and 452 ppm and 1025, 362, and 744 ppm, respectively. After determining the LC_{50} and LC_{25} values of three agents, to evaluate the combined effects of Sirinol, Palizin and Tondexir an experiment was conducted in the form of completely randomized design with eight treatments including LC_{50} (Pal), LC_{50} (Sir), LC_{50} (Ton), LC_{25} (Pal) plus LC_{25} (Sir), LC_{25} (Pal) plus LC_{25} (Ton), LC_{25} (Sir) plus LC_{25} (Ton) and control. Our results demonstrated that Palizin was more effective. The results showed that percentage mortality combination three herbal agents treatments on adult insect compared with Sirinol, Palizin and Tondexir alone and control have significant differences ($P<0.001$).The results showed that the combination of Sirinol, Palizin and Tondexir have good additive effect when compared with applied individually treatments.

Keywords: *Tribolium castaneum*, Tondexir, Sironil, Palizin, LC_{50}, LC_{25}

Introduction
Because of some insufficiencies in protection systems in world transformation and contribution, significant crops are wasted. According to statics in average 35% of agricultural products are waste that this amount of product can supply 15 to 20 million people's food. According to Climate diversity, many herbal species and other abilities in agricultural goods production, has very high capacity of export in agricultural whereas agriculture is economical support for countries and can create many job opportunities (FAO 2009) [6]. Damaged caused by insects, ticks, fungus, and seed's germination in storehouse cause many wastes to stored products (Harein and Meronuck 1995) [8]. Stored products with herbal and animal source are attacked by 600 species of Coleoptera, 70 species of Lepidoptera and 355 species of mites and cause many quantitative and qualitative damages (Rajendran 2002) [15]. Speed of population growth of storehouse pests like Coleoptera and Lepidoptera is very high and consequently amount of caused damage is very high. Kind of stored agricultural products is very effective in pest population growth, because pest quality and quantity can have significant effect in biologic activities and consequently has population density (Cassanova 2002) [5]. Storehouse pest insects in storehouse ambient because of good biologic situation can act whole the year. According to above cases, to reduce the damages, pest population control is inevitable and in this cases using of chemical pesticides is common, it had good effects at first but these results were very unstable because in a short time after using these pesticides many problems were appeared that for example we can name pest resistance, pesticides aggregation in human body, causing many diseases because of remained pesticide on products and increase in cost of pesticides application (Mason and Strait 1998) [13]. In recent years, cereals, especially wheat, rice, malt, and corn has made human's main food, so storehouse building and storage of products for human societies is very important from past times. Science growth and improvement and plantation increase, cause increasing in cereals production but one of the main problems of human from far past up to now is cereals protection in storehouse up to their usage or plantation. Annually more than hundred tons of cereals because of damages of storehouse pests and nonconformity of scientific basics of storage are wasted that because of lack of progress and complement of scientific methods this amount of damage is more in undeveloped countries than developed countries. In these countries existence of warm and

appropriate climate for pest's growth in storehouses with lack of sufficient opportunities for storage and protection of stored productions is the reason (Jayas and Muir 2006) [9]. Damages of storehouse pest in developed countries is 9 percent and in developing countries is more than 20% (Phillips and Thoren 2010). *Tribolium castaneum* is a little beetle with length of 3 to 4 mm and with color of reddish brown. Larva and adult insects of this specie, feed from different storehouse productions like oil seeds, dried fruits, cereals seeds and flour, and beside direct damage it cause reducing in production's marketability (Adler 1994) [1]. In this study sensitivity *Tribolium castaneum* (Herbest) toward three herbal insecticides Sirinol, Palizin and Tondexir were evaluated under laboratory conditions.

Material and Methods
The present study was carried out in entomology lab of agriculture faculty, plant protection departments of Urmia University at summer of 2015 in Iran.

Insect rearing
The red flour beetle, *T. castaneum* was used for the present experiments. A colony of *T. castaneum* was obtained from storage products in the laboratory of Urmia University. They were reared under storage conditions, on red flour beetle at 27±2 °C, with L: D 14: 10 and 65±5% RH.

Insecticides tested
In This study, the botanical insecticides of Sirinol (garlic extract) with Formulation (EC), Tondexir (pepper extract) with Formulation (EC) and Palizin (eucalyptus extract) with Formulation WS (water soluble) were used (kimia Sabzavar Co., Iran.) to control of *T. castaneum*. These insecticides are considered nontoxic to mammals (rat oral acute LD_{50} is >5000 $mg.kg^{-1}$). 2500 CC/1000L water was used for each insecticide.

Test of LC_{50} and LC_{25}
To estimate the LC_{50} and LC_{25} five concentration from each botanical insecticides after primary experiments with distill water as control treatment in three replication used in filter paper dipping method on 10 adult pests in petri dish and mortality recorded after 24 hours (Finney 1971) [7].

The interaction effects between Sirinol, Palizin and Tondexir
After calculating LC_{50} and LC_{25} values for Sirinol, Palizin and Tondexir on adult stages combination effects of Sirinol plus Palizin, Tondexir plus Sirinol, Palizin plus Tondexir by filter paper dipping method in petri dish were evaluated. All experiments in completely randomized design in 8 treatments include LC_{50} of Sirinol, LC_{50} of Palizin, LC_{50} of Tondexir, LC_{25} Sirinol plus LC_{25} Palizin, LC_{25} Tondexir plus LC_{25} Sirinol, LC_{25} Palizin plus LC_{25} Tondexir and distilled water as control in three replications After drying, filter papers were put in petri dishes and 10 of adult *T. castaneum* was selected and added and petri dishes were covered completely with parafilm glue. After 24 hours percentage of mortality was recorded.

Analysis of Data
The LC_{50} and LC_{25} values (with 95% confidence limits) were calculated by using Probit Analysis Statistical Method, mortality data treatments subjected to analysis of variance (One Way ANOVA) and mean separation tests were conducted with Tukey's HSD with SPSS statistical analysis software (Version 22.0).

Results
Bioassay
LC_{50} and LC_{25} Sirinol, Palizin and Tondexir on adult stage
LC_{50} and LC_{25} of Sirinol, Palizin and Tondexir on adult stages in three times are shown in Table 1.

Table 1: LC_{50} and LC_{25} Values calculated Sirinol, Palizin and Tondexir effect on adult red flour beetle within 24 hours

Insecticide	Time (hours)	Slope±SE	Chi-square	Lethal concentration (ppm)	
				LC_{25} 95% confidence interval	LC_{50} 95% confidence interval
Sirinol	24	1. 89±0.187	0.291	451 (353.05-542.11)	1025 (892.98-1202.29)
Palizin	24	4.733±0.351	0.245	262 (235.50-283.41)	362 (336.98-387.91)
Tondexir	24	3.13±0.417	0.105	452 (416.74-536.85)	744 (672.02-775.95)

Interaction effects of Sirinol, Palizin and Tondexir on *T. castaneum* in 24 H
Effects of treatments, Sirinol LC_{50}, Tondexir LC_{50}, Palizin LC_{50} and Sirinol plus Palizin, Tondexir plus Sirinol, Palizin plus Tondexir on *T. castaneum* was evaluated and counting the percentage mortality after 24H (fig. 1). The results showed that there was a significant difference between LC_{25} Sirinol+LC_{25} Palizin, LC_{25} Sirinol+LC_{25}Tondexir and LC_{25} Palizin+LC_{25} Tondexir treatment with alone application treatments LC_{50} Sirinol, LC_{50} Tondexir and LC_{50} Palizin with 99% confidence in 24 H [$F(6, 14) = 19.389$, p=0.001)]. According to result showed that combined effects of treatments the highest mortality compared with other treatments.

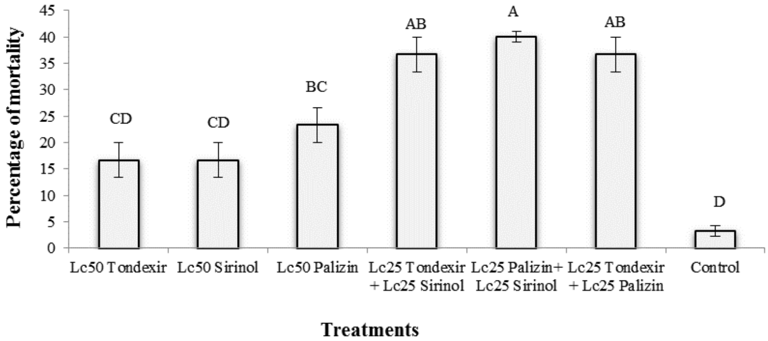

Fig 1: Interaction effects of Sirinol, Palizin and Tondexir on *T. castaneum* in 24 H

Interaction effects of Sirinol, Palizin and Tondexir on *T. castaneum* in 48 H

Effects of treatments, Sirinol LC_{50}, Tondexir LC_{50}, Palizin LC_{50} and Sirinol plus Palizin, Tondexir plus Sirinol, Palizin plus Tondexir on *T. castaneum* was evaluated and counting the percentage mortality after 48H (fig. 2). The results showed that there was a significant difference between LC_{25} Sirinol+LC_{25} Palizin, LC_{25} Sirinol+LC_{25}Tondexir and LC_{25} Palizin+LC_{25} Tondexir treatment with alone application treatments LC_{50} Sirinol, LC_{50} Tondexir and LC_{50} Palizin with 99% confidence in 48 H [$F(6, 14) = 12.611$, p=0.001]. According to result showed that combined effects of treatments the highest mortality compared with other treatments.

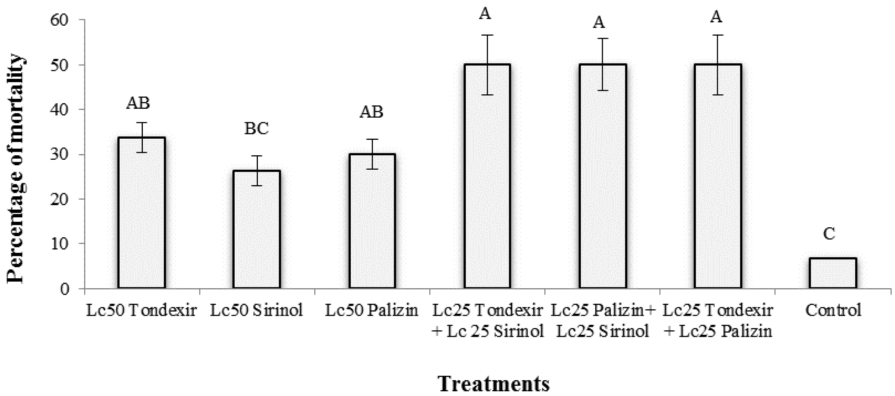

Fig 2: Interaction effects of Sirinol, Palizin and Tondexir on *T. castaneum* in 48 H

Interaction effects of Sirinol, Palizin and Tondexir on *T. castaneum* in 72 H

Effects of treatments, Sirinol LC_{50}, Tondexir LC_{50}, Palizin LC_{50} and Sirinol plus Palizin, Tondexir plus Sirinol, Palizin plus Tondexir on *T. castaneum* was evaluated and counting the percentage mortality after 72 H (fig. 3). The results showed that there was a significant difference between LC_{25} Sirinol+LC_{25} Palizin, LC_{25} Sirinol+LC_{25}Tondexir and LC_{25} Palizin+LC_{25} Tondexir treatment with alone application treatments LC_{50} Sirinol, LC_{50} Tondexir and LC_{50} Palizin with 99% confidence in 72 H [$F(6, 14) = 18.667$, p=0.001]. According to result showed that combined effects of treatments the highest mortality compared with other treatments.

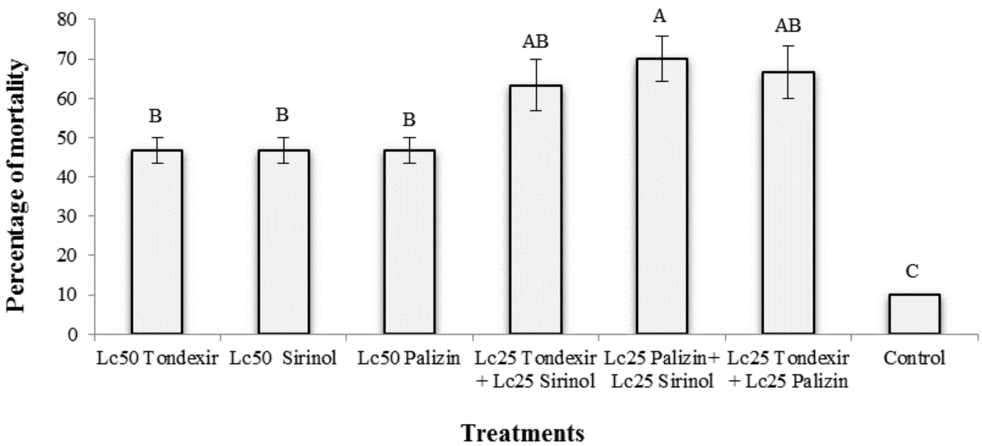

Figure 3. Interaction effects of Sirinol, Palizin and Tondexir on *T. castaneum* in 72 H

Discussion

Reviewing the previous results it could be concluded that Sirinol, Tondexir and Palizin had potential effect when integrated with each other that increased the reduction in infestation rates with *T. castaneum*. Kabiri and Amiri-Besheli (2012) [10] indicated Palizin (2500 ppm) caused 84.93±0.65% mortalities on the pistachio psyllid nymphs in laboratory conditions that is in agreement with this study. Also, Kabiri and Amiri-Besheli (2012) [10] reported Palizin provides a physical and chemical barrier against insect pests and shows considerable potential for effective control of insect pests in certain agricultural crops. Other advantages of Palizin are that pests are unlikely to develop resistance to it, it has no phytotoxic effects, it lasts longer than most insecticides on plants when it does not rain or there is no excessive dew, is nontoxic to humans and is relatively harmless to natural enemies. Amiri-Besheli (2009) [3] reported that the effect of Palizin, Tondexir and Sirinol on *Phylocnistis citrella* Stainton caused 76.25±3.4%, 81±7.29% and 71±11.42% mortalities after 96 hours in laboratory conditions, respectively. Also, the results of Ahmadi *et al.*, (2012) [2] showed that Palizin, Tondexir and Sirinol treatments on *Planococcus citri* (Risso) caused 86.16%, 90.6% and 87.11% mortalities, respectively. The results of these researchers are consistent with this study. The effects of garlic and pepper extracts have been investigated in other studies. Garlic produces a variety of volatile sulfur based compounds, which are effective as insect repellents and insecticides (Kazem and El-Shereif 2010) [11]. Kiani *et al.* (2012) [12] reported garlic, pepper and onion extracts significantly control *Frankliniella occidentalis* (Pergande). Also, Antonious *et al* (2007) [4] investigated the effect pepper extract on cabbage looper, *Trichopulsia ni* (Hubner) and spider mite, *Tetranychus urticae* (Koch) and reported that this extract caused 94% mortality in *T. ni* and showed repellency effect on *T. urticae*. Osipitan and Mohammed (2008) [14] indicated the insecticidal, repellence, antifeedant, and fumigative effects of garlic. The combination of Palizin and Sirinol were most effective in the mortality of *T. castaneum* than Sirinol and Tondexir, Palizin and Tondexir. Therefore, further studies should be carried out to integrate this strategy with other integrated or biological control methods in order to reduce the use of chemicals and, consequently, improve food safety and environment quality. We recommend use of combination three herbal agents in control of this pest. Our current study indicated that the concept of integrating herbal Sirinol, Palizin and Tondexir with other control tactics, especially with environmentally acceptable agents has opened further opportunities for their uses as biological control agents of insect pest.

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