Acaridical activity of plant extracts to control Date palm fruit dust mite Oligonychus afrasiaticus (McGregor) (Acari Tetranchidae)

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Research Article

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Abstract

This study aimed to determine the variables that influence the mortality rate of *Oligonychus afrasiaticus* (McGregor) (Acari Tetranchidae) dust mites and to explore potential control options for this pest. The important variables that were examined at included plant species, extraction method, concentration, and time. The findings indicated noteworthy impacts of these variables on the mortality rates of dust mites. The mortality rates of dust mites were significantly affected by the type of plant species ($p < 0.01$). The highest mortality rates were observed with *Cymbopogon citratus*, whereas there was no significant variation between *Vitexm agnus-castus* and *Melilotus officinalis*. The extraction method was Influential (*p < 0.01*), with ethanol extract performing better than aqueous and hexane extracts in terms of efficacy. Aqueous extraction had a lower efficacy than hexane extraction. The concentration of plant extract considerably affected the mortality rates of dust mites ($p < 0.01$). increased concentrations led to significantly increased mortality rates, demonstrating a concentration-dependent impact. Dust mite mortality rates were also affected by exposure duration (p 0.01). When the exposure period was increased, the mortality rate increased considerably. Significant differences in mortality rates have been observed for each time period (6, 12, 24, and 48 hours). These findings emphasize the importance of selecting appropriate plant species, utilizing effective extraction methods, optimizing concentration levels, and considering exposure duration for designing efficient dust mite control strategies. *Cymbopogon citratus*, especially when extracted with ethanol and applied at higher concentrations, has the potential to be a natural dust mite control treatment.

Introduction

Phoenix dactylifera L., commonly known as the date palm, is a significant crop in regions with arid and semi-arid climates. It acts as an essential provider of nourishment, revenue, and job opportunities for countless people across the world. (Abdel-Baky et al, 2023). The presence of pests and diseases poses a significant challenge to this cultivation, with the dust mite *Oligonychus afrasiaticus* (McGregor) being a major cause for concern (El-Shafie, 2022). This mite feeds on the leaves and fruits of the palm tree, resulting in extensive damage to the quality and yield of the fruit (Mohammed et al., 2023).. Commonly used techniques for controlling *O. afrasiaticus* involve the use of chemical insecticides, which have the potential to cause harm to the environment, non-target organisms, and human health (Pathak et al., 2022). As a result, there is a growing interest in exploring alternative pest management methods, such as the utilization of natural plant extracts with acaricidal properties (Ngegba et al., 2022).

Earlier investigations have examined the effectiveness of various botanical extracts on different species of mites, laying the groundwork for prospective studies on their potential usefulness in controlling dust mites. According to Lakhdari et al. (2015), a water-based botanical extract sourced from *Zygophyllum album* L demonstrates a mortality rate of 76% against the date palm mite. Topuz et al. (2018) investigated the acaricidal efficacy of essential oil for five plant species, including *Vitex agnus-castus*, against *Tetranychus urticae* Koch (Acari: Tetranychidae), and their results were promising. Furthermore, Rincón et al. (2019) evaluated the acaricidal efficacy of *Melilotus officinalis* extracts on *Tetranychus*

urticae, emphasising the plant's potential as a natural control agent. Hanifah et al. (2011) investigated the acaricidal properties of essential oils from *Cymbopogon* species against house dust mites, indicating their efficiency in mite management.

The objective of this research was to investigate at the factors that affect the mortality rate of dust mites *Oligonychus afrasiaticus* (McGregor) (Acari Tetranchidae) and to look into potential management solutions for this pest. The research looked at the effects of plant species, extraction technique, concentration, and exposure period on dust mite mortality rates.

Materials and methods

Collection and Preparation of Plant Materials:

Plant samples were obtained from several areas around the Basrah governorate-IRAQ, including *Vitex agnus-castus, Melilotus officinalis*, and *Cymbopogon citratus*. To maintain the phytochemical composition of the obtained plant material, it was properly cleaned to eliminate any dirt or debris and air-dried under shade.. Once dried, the plant material was ground into a fine powder using a grinder or mortar and pestle.

Extraction and Concentration of Plant Extracts:

to extract the active ingredients from the plant material, 100 grams of the powdered material was taken. Three procedures of extractions were performed: hexane, water and alcohol (ethanol 70%) extraction. For the water extraction, the plant material was macerated in 400 ml of lukewarm distilled water in an Erlenmeyer flask. The flask was agitated at 100 rpm for 24 hours. After filtering through a Buchner funnel and Whatman No. 1 filter paper, the extract was concentrated under low pressure using a rotary evaporator. For the alcohol extraction, the same procedure was followed, except that 70% ethanol was used instead of water. The crude extracts from both extractions were reconstituted to have a concentration of 20% (w/v) using distilled water. The required concentrations (1, 2, 3, and 4%) were then prepared from the stock solutions by diluting with distilled water. Finally, 1 ml of Tween 80 and one drop of paraffin were added to each solution.

Dust Mite Culture:

In order to conduct the experiments, a laboratory culture of the spider mite Oligonychus afrasiaticus was established and maintained. The mites were collected from infested date palm trees in farms located within Basrah Governorate and transferred to a culture setup. The culture setup provided a controlled environment with suitable conditions such as temperature (25 ± 2°C), relative humidity (70 ± 5%), and photoperiod (16:8 light:dark) for the growth of the mites. Date palm seedlings were provided as a source of nutrition, and the culture was regularly monitored for population growth.

Dust Mite Bioassay:

Individual dust mites (20 individuals per petri dish) were placed in a petri dish with a diameter of 9 cm. Pieces of date palm leaves were added to the petri dish as a food source for the mites. Each dish represented a specific treatment with one concentration of the plant extract. The extract concentrations were sprayed evenly onto the date palm leaves using a fine mist sprayer, ensuring adequate coverage. Petri dishes representing control groups were treated with distilled water or ethanol, depending on the type of extract used. The treated petri dishes were kept in a controlled environment with suitable temperature and humidity.

Mortality Assessment:

Mite mortality was recorded at different time intervals, specifically at 6, 12, 24, and 48 hours after treatment. Dead mites were identified by their lack of movement and responsiveness to touch. The number of dead mites was counted and recorded for each treatment and time point.

Data Analysis:

The result data was subjected to statistical analysis using analysis of variance (ANOVA), which was followed by a post-hoc analysis using the Least Significant Difference (LSD) test. $P < 0.01$ was used as the significance probability.

Results

In the current study, the effects of four factors—plant species, extraction procedure, concentration, and time—were examined in relation to dust mite mortality rates. The data collected for each factor provided crucial information about the efficacy of dust mite control.

1. Plant species

According to Fig. 1, the plant species significantly affected the mortality rates of date palm dust mites. The three plant species tested—Cymbopogon citratus, Vitex agnus-castus, and Melilotus officinalis—had average mortality rates of 39.55%, 37.80%, and 37.91%, respectively. Significant variances among the studied plant species were observed by post-hoc analysis (LSD = 1.12, $p < 0.01$). Compared to Vitex agnus-castus and Melilotus officinalis, Cymbopogon citratus showed significantly greater mortality rates (p 0.01). However, there was not a significant difference between Melilotus officinalis and Vitex agnus-castus in terms of their effected on dust mite mortality rate.

2. Extract

The method employed of the extract played a crucial role in managing dust mites (LSD = 1.25, $p < 0.01$). According to Fig. 2, the mean mortality percentages for the aqueous, alcohol, and hexane extractions were 3.27%, 46.35%, and 36.65%, respectively. Further analysis revealed that the use of ethanol extraction resulted in significantly greater mortality percentages compared to both aqueous and hexane extractions

($p < 0.01$). hexane extraction demonstrated moderate efficiency, while aqueous extraction exhibited relatively lower effectiveness.

3. Concentration

The effectiveness of the plant extracts on the mortality rates of dust mites was significantly influenced by their concentration (LSD = 1.45, $p < 0.01$). The average mortality rates for the various concentrations, including 1%, 2%, 3%, and 4%, were 28.82%, 34.28%, 41.99%, and 48.61%, respectively (Fig. 3). Further analysis showed that higher concentrations led to significantly higher mortality rates in comparison to lower concentrations ($p < 0.01$). Specifically, mortality rates significantly rose from 1–2%, 2–3%, and 3–4% concentrations.

4. Time

The duration of exposure to plant extracts, indicated by time intervals of 6, 12, 24, and 48 hours, impacted dust mite mortality rates (LSD = 1.45, p 0.05). As shown in Fig. 4, the grand mean mortality rates at different time periods were 16.47%, 33.76%, 45.76%, and 57.62%, respectively. Post-hoc analysis indicated that as exposure duration increased, dust mite mortality rates increased significantly (p 0.05). There were substantial changes in mortality rates among time intervals, indicating a time-dependent impact.

Table 1. displays revealed that the highest mortality rate was observed for Cymbopogon citratus (95.61%), recorded in the ethanol extract at a concentration of 4% after 48 hours. In contrast, the lowest mortality rate for Cymbopogon citratus was 11.31%, observed in the aqueous extract at a concentration of 1% after 6 hours. Vitex agnus-castus showed a maximum mortality rate of 73.27% in the ethanol extract at a concentration of 4% after 48 hours, while the lowest rate of 9.13% was observed in the aqueous extract at a concentration of 1% after 6 hours. Regarding Melilotus officinalis, the greatest mortality rate (67.65%) was noted in the water-based solution with a 4% concentration after 48 hours, whereas the least rate (9.21%) was observed in the water-based solution with a 1% concentration after 6 hours. These results imply that distinct botanical varieties have varying efficacy levels in causing the demise of dust mites.

Table 1
effect of plant species, extract, concentration and time on the mortality rate (%) of date palm dust mite.

Plant species	Extract	Concentration	Intervals			
			6	12	24	48
Cymbopogon citratus	hexane	1	13.48	17.66	32.66	37.94
		2	16.87	23.67	29.28	51.22
		3	21.97	27.07	45.27	60.40
		4	27.07	33.87	50.54	62.95
	ethanol	1	14.98	33.78	41.38	53.55
		2	17.13	38.97	61.08	71.12
		3	18.57	49.18	71.29	85.40
		4	25.37	57.68	73.84	95.61
	Aqueous	1	11.31	16.33	31.16	38.95
		2	11.77	27.07	32.68	41.53
		3	18.57	38.98	42.21	50.20
		4	21.97	49.18	49.69	60.06
Vitex agnus-castus	hexane	1	14.14	17.51	29.50	37.61
		2	14.67	23.17	29.97	50.38
		3	19.77	28.27	43.58	58.88
		4	23.17	33.37	48.68	60.58
	ethanol	1	12.46	37.63	46.21	51.04
		2	14.67	36.77	58.88	67.46
		3	18.07	48.68	62.79	69.63
		4	26.57	55.48	70.49	73.27
	Aqueous	1	9.13	17.51	29.50	37.61
		2	12.97	26.57	31.67	40.18
		3	16.37	36.77	40.18	48.68
		4	18.07	50.38	54.80	61.09
Melilotus officinalis	hexane	1	12.88	28.02	39.93	47.75

	2	13.91	34.14	42.78	53.61
	3	14.59	34.37	50.13	63.57
	4	20.54	36.86	58.12	75.04
ethanol	1	22.11	25.64	37.93	46.24
	2	23.26	31.76	39.07	59.31
	3	27.68	37.20	52.68	67.31
	4	31.93	42.48	57.44	67.65
Aqueous	1	9.21	16.92	29.06	37.18
	2	13.40	26.15	31.42	40.27
	3	16.80	36.69	39.42	44.93
	4	18.84	49.62	48.43	65.87

Discussion

In this study, we investigated the effects of different plant species, extraction methods, concentrations, and exposure times on dust mite mortality.

1. Plant species

The study results show that there are significant differences in the efficiency of different plant species in reducing dust mites. Among the investigated plant species, Cymbopogon citratus had significantly higher death rates than Vitex agnus-castus and Melilotus officinalis (p 0.01). The findings show that the ethanol extract extracted from C. citratus leaf is toxic to dust mites.

2. Several previous investigations found that *C. citratus* has insecticidal and acaricidal activity against mites and other pests (Hanifah et al., 2011; Moustafa et al., 2021). a diverse range of bioactive compounds present in C. citratus, such as alcohols, ketones, esters, aldehydes, saponins, terpenoids, terpenes, neryl, nerol, myrcene, geraniol, citral, gernyl acetate, and numerous flavonoids (Shah et al., 2011; Hussain et al., 2023). Terpenoids have particular interest since they have been shown to possess acaricidal properties (Zieliska et al., 2018). The results of this study are consistent with the results of many studies that indicated the effectiveness of lemongrass leaf extract had the best acaricidal effect against species of mites such as house dust mites (Hanifah et al., 2011) and *Panonychus citri* (McGregor) (Acari: Tetranychidae). (Zhu et al., 2023), the African red mite (*Eutetranychus africanus*) (Doungnapa et al., 2021), and the scabies mite.

3. Extracts

In relation to the extract factor, the ethanol extract outperformed the aqueous and hexane extracts in terms of causing dust mite mortality. Ethanol has been shown to extract a wide range of bioactive substances from plant material, including phenolic compounds, alkaloids, and terpenoids (Stéphane et al., 2022). Acaricide activities have been observed for these bioactive substances (Tomczyk & Suszko, 2011). The acaricide potential of plant extracts obtained by ethanol from diverse plants has been demonstrated in several previous studies (Deka et al., 2022). The presence of these compounds with acaricide activities, including terpenoids, may explain the higher mortality rates observed in the ethanol extract.

4. Concentration

In regard to concentration, a significant positive association has been found between extract concentration and dust mite mortality rate. Higher concentrations (3% and 4%) resulted in more fatalities when compared to lower values (1% and 2%). This finding is similar with previous study that revealed concentration-dependent insecticidal activity in plant extracts (Lakhdari et al., 2015; Moustafa et al., 2021; Deka et al., 2022). Higher concentrations may result in higher quantities of bioactive chemicals in extracts, which may lead to enhanced toxicity against dust mites (Ngegba et al., 2022).

5. Time

In terms of the time factor, longer exposure times resulted in greater dust mite mortality rates. As the duration of exposure escalated from 6 to 48 hours, there was a increased in the death rate of dust mites. This finding suggests that plant extracts' bioactive compounds necessitate time to manifest their acaricidal actions on dust mites (Fu et al., 2021). Likewise, studies examined the acaricidal efficacy of plant extracts against other pests have yielded comparable results (Hanifah et al., 2011; Zhu et al., 2023). Prolonged exposure enables the bioactive substances to penetrate and interact more extensively with the physiological processes of the dust mites, leading to increased mortality rates (Jian et al., 2022).

Conclusion

The present investigation offers an understanding of the factors that impact the mortality rates of dust mites. The effectiveness of controlling dust mites was assessed based on the species of plants used, the method of extraction, the concentration, and the duration of exposure. Of all the plant species examined, *Cymbopogon citratus* exhibited the highest mortality rate. Ethanol extraction proved to be more effective than aqueous and hexane methods. Increased concentrations of the plant extracts resulted in higher mortality rates, while longer exposure periods had a significant impact on dust mite mortality as well. These findings highlight the need of taking these parameters into consideration when developing efficient dust mite control strategies. Additional research and development in this field may result in the development of long-lasting and efficient techniques for controlling dust mite infestations.

Declarations

Ethical Approval

Not applicable

Competing interests

Not applicable

Authors' contributions

Hazim M. Ali was responsible for the conceptualization and design of the research, overseeing the data collection and analysis, and writing the manuscript. Khalid A. Fhaid contributed to the data collection, conducted statistical analyses, and provided critical input in interpreting the results. Khairullah M. Awad participated in the literature review, contributed to the experimental design, and assisted in manuscript preparation and revision. All authors reviewed and approved the final version of the manuscript before submission.

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Availability of data and materials

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Figures

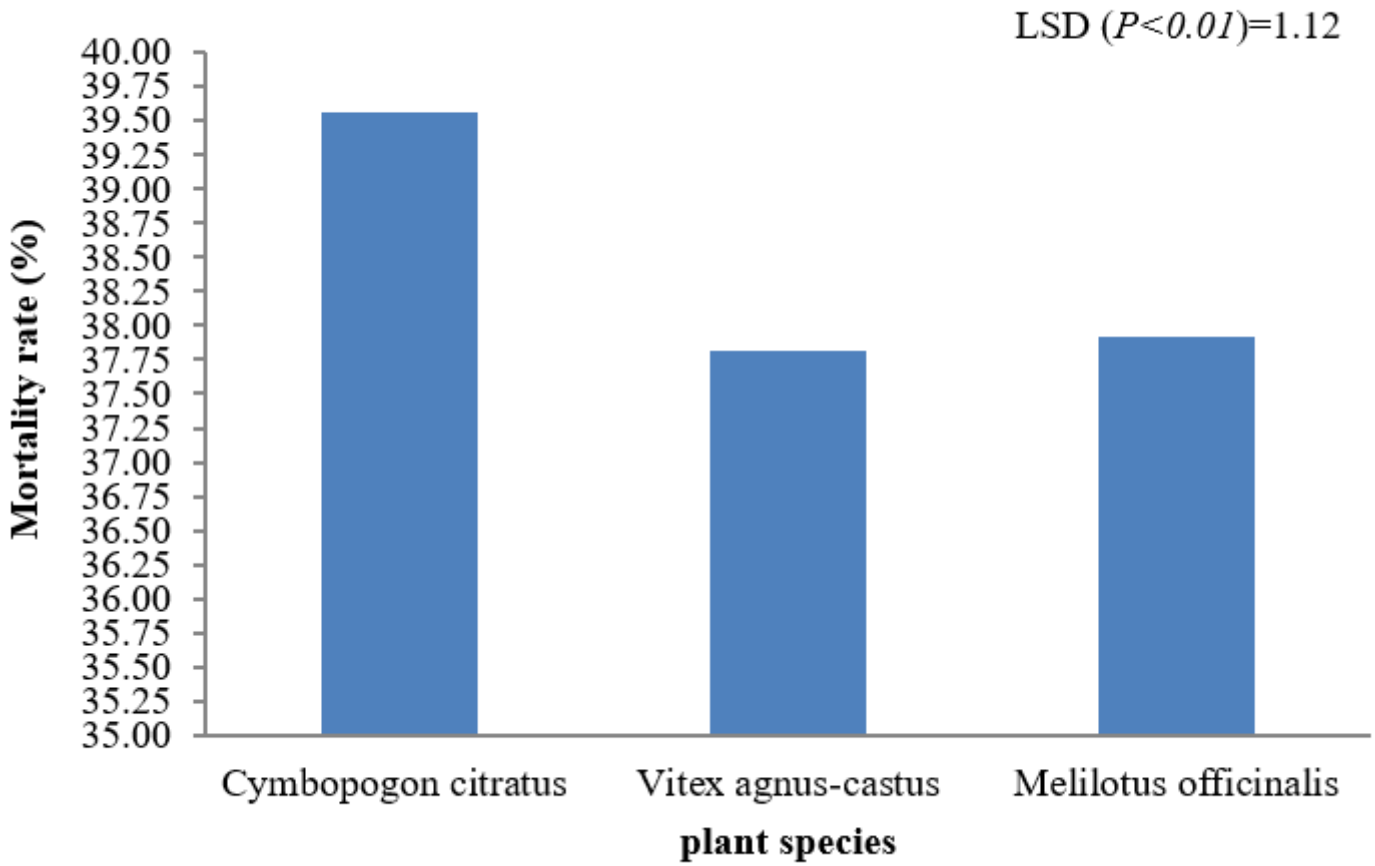

Figure 1

Impact of plant species on mortality rate (%) of date palm dust mite.

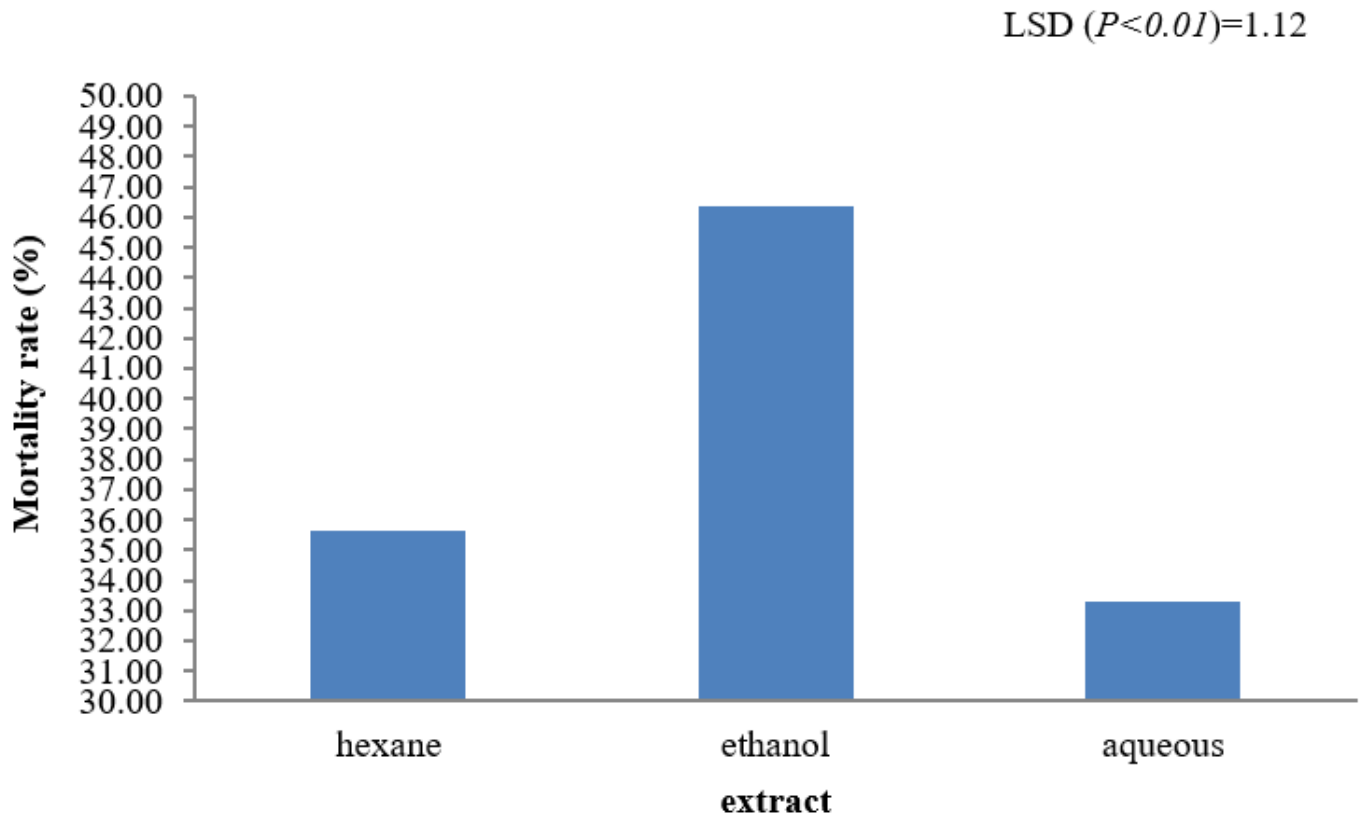

Figure 2

Impact of extract on mortality rate (%) of date palm dust mite.

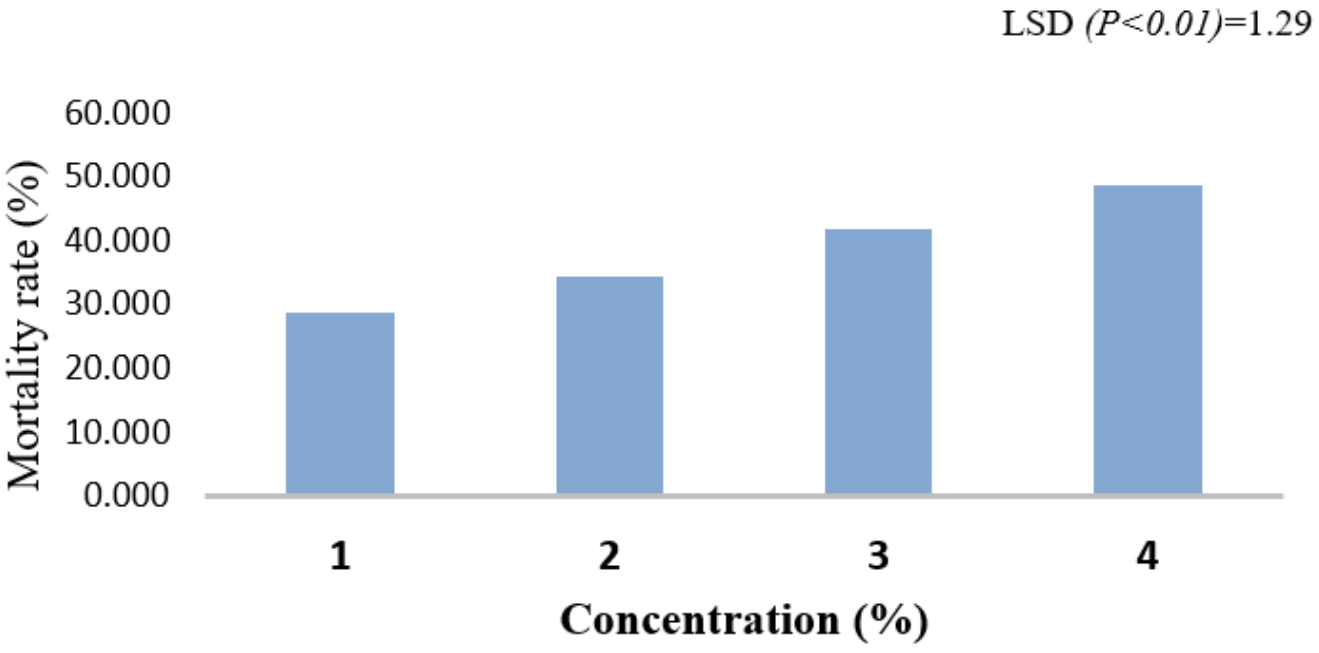

Figure 3

Impact of extract concentration on mortality rate (%) of date palm dust mite.

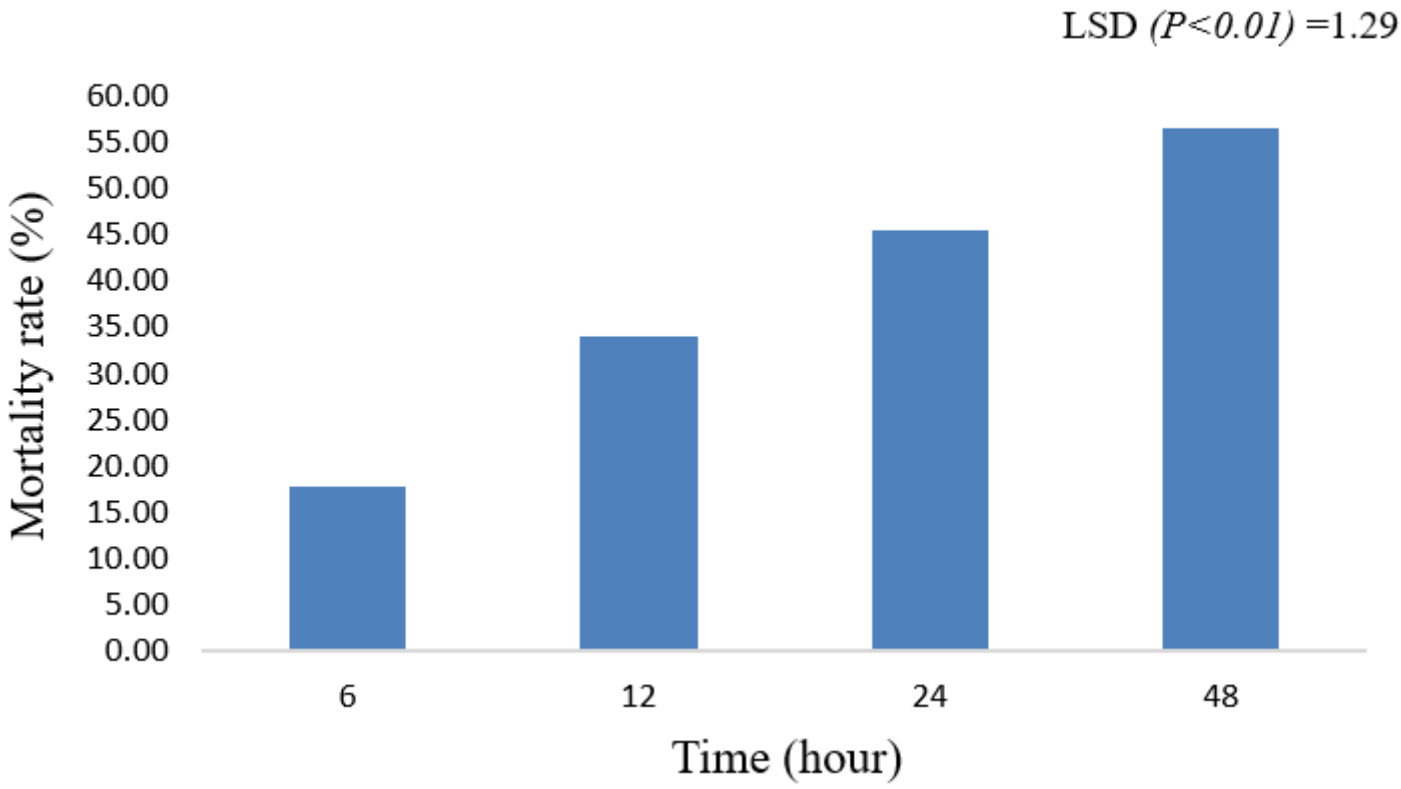

Figure 4

Impact of time of exposure on mortality rate (%) of date palm dust mite.