

Research Article

Comparative insecticidal efficacy of conventional and ultrasound-assisted ethanolic extracts of different growth stages of *Melia azedarach* on mortality of *Aphis fabae* nymphs

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Abstract: The insecticidal effects of Conventional Ethanolic Extract (CEE) from five growth stages of *Melia azedarach* (including flower, small green fruit, big green fruit, ripe fruit, and leaf) on nymphs of *Aphis fabae* were investigated. In 1-2 day-old nymphs, no significant differences in mortality rates among the extracts were found, with the leaf extract showing the highest mortality rate of $65.24 \pm 5.89\%$. In 3-4-day-old nymphs, the ripe fruit extract had the highest mortality rate at $88.5 \pm 2.79\%$, while the small green fruit extract had the lowest at $31.83 \pm 4.17\%$. Additionally, the insecticidal effects of ethanolic extracts from the five growth stages of *M. azedarach* were tested using Ultrasound-Assisted Extraction (UAE). For 1-2-day-old nymphs, significant differences were noted between the control and ethanol treatments ($P \geq 0.0001$), with lower mortality than the extracts ($P \geq 0.00001$). The leaf extract recorded the highest mortality rate ($98.0 \pm 1.33\%$), while the big green fruit extract had the lowest ($87.5 \pm 4.61\%$). In 3-4 day-old nymphs, the results mirrored previous findings, showing significant differences ($P \geq 0.0001$) with higher mortality rates from the extracts ($P \geq 0.00001$). Again, the leaf extract had the highest efficacy ($96.9 \pm 1.30\%$), while the small green fruit extract had the lowest ($86.8 \pm 4.72\%$). When comparing the insecticidal effects of ethanolic extracts obtained through CEE and UAE on *A. fabae*, the data showed that, except in two cases, UAE significantly increased mortality rates compared with CEE ($P \geq 0.0001$).

Keywords: Botanical insecticides, Conventional extraction, Ultrasound-assisted extraction (UAE), Mortality, *Aphis fabae* Scopoli

Introduction

Aphis fabae Scopoli is among the various pests that impact cultivated agricultural products globally (Blackman and Eastop, 2007). This aphid infests a wide range of plants; over 200 species worldwide and approximately 50 species in Iran are

susceptible (Hodjat, 1986). Currently, control measures for *A. fabae* Scopoli rely on numerous pesticides. However, this practice can inadvertently increase target pest populations, promote the emergence of secondary pests, and drive pesticide resistance in the target pest (Schepers, 1989; Hardin *et al.*, 1995; Longley *et al.*, 1997).

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The indiscriminate application of non-selective pesticides has resulted in the destruction of natural enemies, contributing to a continuous rise in pest populations. Moreover, the misuse and overuse of chemical pesticides adversely affect agricultural ecosystems and human health. Pesticide residues found in agricultural products, especially fresh fruits and vegetables, can heighten the risk of cancer in humans (Dadang *et al.*, 2009). Therefore, it is vital to implement long-term, healthy, low-risk, effective, and natural pest control strategies.

Melia azedarach, a plant native to Australia and southeastern Asia, is recognized for its significant pesticidal properties (Lee *et al.*, 1991; Schmutterer, 1989; Valladares *et al.*, 1997). The insecticidal effects of *M. azedarach* are primarily attributed to compounds such as azadirachtin, salannin, and melianthrol, which disrupt insect growth and reproduction (Isman *et al.*, 1996). While its antinutritional properties and effects on insect development are well documented, the molecular mechanisms underlying these effects remain largely unexplored (Hoffmann and Lorenz, 1998; Deshmukh and Renapurkar, 1987; Nicoletti, 2020).

Traditional extraction methods, including Conventional Extraction and Soxhlet Extraction, have been employed for many years but are often time-consuming and require substantial amounts of solvent (Bitwell *et al.*, 2023). Growing environmental concerns and inefficiencies in these methods have increased demand for new extraction techniques that minimize time and solvent use while being more eco-friendly. One such innovative approach is Ultrasound-Assisted Extraction (UAE) (Vinatoru, 2001). This method enhances extraction efficiency and quality while reducing the time and solvent required. UAE has emerged as a crucial technique for extracting valuable compounds from plant resources (Vilkhu *et al.*, 2008). UAE devices are available in two forms: Probe and Bath, suitable for both industrial and laboratory applications (Wu *et al.*, 2022; Vinatoru, 2001). Ultrasound waves above 20 kHz penetrate plant tissues, creating cycles of compression and expansion that lead to

cavitation—the formation of tiny bubbles that grow to a critical size and then collapse, releasing significant energy into the surrounding environment (Zhang *et al.*, 2017). This cavitation accelerates plant cell breakdown, promoting rapid compound release. Numerous studies have confirmed the advantages of UAE, which include reduced extraction time, increased yield, and minimized solvent consumption (Chemat *et al.*, 2017). For example, Vilkhu *et al.* (2008) emphasized that ultrasound waves create strong, localized turbulence that enhances mass transfer. Additionally, Shotipruk *et al.* (2001) demonstrated that cavitation occurring near solid particles generates micro-jets that can break down cell walls, further improving extraction efficiency. Several factors influence the effectiveness of UAE, including the moisture content of the plant material, particle size, and extraction duration. Moisture is particularly important, as ultrasound energy diminishes with distance from the source and is absorbed more effectively in denser materials. Using moistened plant tissue (plant material plus solvent) can help maintain ultrasound energy, and reducing particle size can enhance extraction efficiency (Bitwell *et al.*, 2023). Temperature control is crucial, as excessive heat may degrade extract quality (Gil-Martín *et al.*, 2022). Recent studies show that UAE can effectively extract various compounds from plant tissues, including essential oils and bioactive compounds (Chemat *et al.*, 2017; Gil-Martín *et al.*, 2022; Wu *et al.*, 2022). Moreover, solvent choice significantly influences ultrasound extraction efficiency, with certain solvents enhancing the yield of specific compounds (Tavares *et al.*, 2021).

This study investigates the pesticidal effects of the extracts from five growth stages of *M. azedarach* L. (flower, small green fruit, big green fruit, ripe fruit, and leaf) using an ethanolic solvent. The research compares two extraction methods—conventional extraction and ultrasound-assisted extraction. The efficacy of these extracts was tested under laboratory conditions on 1- to 2-day-old and 3- to 4-day-old nymphs of *A. fabae* (black bean aphid).

Materials and Methods

Insect rearing

To investigate the influence of extracts from different growth stages of *M. azedarach* on insect control, *A. fabae* was used. To rear insects under laboratory conditions, aphids were collected from the experimental teaching greenhouse of Shahid Bahonar University of Kerman, Kerman, Iran (30°19'51.33" N, 56°55'41.72" E, elevation 1776 m). Expert colleagues in the Plant Protection Department, who specialize in aphid taxonomy, identified *A. fabae*. After relocating the aphids to the laboratory, we established a colony. Broad bean leaves (*Vicia faba* Linnaeus var. *major* Harz) were used as the food source for rearing the aphids in special rearing containers (plastic containers with a diameter of 6 cm and a height of 4 cm, containing 0.7% agar gel). The agar gel was used to maintain moisture and keep the host plant leaves viable for a longer period. Typically, 10 to 15 adult aphids were placed in each container for mass rearing. The container openings were covered with special lace (transparent silk) to allow for adequate air circulation. Subsequently, the containers were placed in a growth chamber maintained at 25 ± 1 °C and $50 \pm 10\%$ relative humidity, under a photoperiod of 16 hours of light and 8 hours of darkness. Aphids were reared for approximately one week under controlled conditions. As their population increased, the rearing medium—fresh host plant leaves and agar gel—deteriorated. To maintain suitable conditions and keep the aphids healthy, we periodically transferred adults to fresh Petri dishes containing new leaves and agar gel. This routine was maintained throughout the rearing period to ensure the colony remained vigorous.

To ensure age uniformity, 200 adult aphids from the initial colony were isolated and kept in a separate colony. After 24 hours, the adults were removed and returned to the main colony. The nymphs produced during this period, aged 1 to 2 days, were used for testing. To prepare 3- to 4-day-old nymphs, the 1- to 2-day-old nymphs were kept in a separate colony, and after 48

hours, they reached the desired age and were utilized for the experiments.

Preparation of plant samples

Various growth stages of *M. azedarach*—including flower, small green fruit (with an average diameter of 3 mm), large green fruit (with an average diameter of 7 mm), ripe fruit, and leaf—were collected from their natural habitat in Mahan (Kerman province, latitude 30°3'36" N, longitude 57°17'27" E, 1794 m altitude) for subsequent experiments. The flower samples of *M. azedarach* were collected in late April, while the unripe fruits and leaves were collected in May and June. The ripe fruit samples were gathered in November. Different growth stages of the fruit were specifically selected for testing, as they vary in chemical composition. This selection allows for examining how these compositional differences impact insect responses. The plant materials were transported to the laboratory, where they were dried at room temperature under shade and ventilation conditions. Once fully dried, the plant parts were ground into a fine powder using an electric stainless steel mill.

Preparation of plant extracts by conventional extraction

For each growth stage of the fruit, as well as for the flower and leaf of the plant, 70 g of powdered plant material was placed into a 500 mL flask. Ethanol (96% v/v; Kimia Alcohol Co., Iran) was added to each flask to a total volume of 150 mL. Ethanol was chosen as the solvent because it effectively extracts a wide range of phytochemicals from plant materials. The mixture was stirred for one hour to ensure thorough extraction. After stirring, the flask lids were sealed with Parafilm® to prevent solvent evaporation, which is crucial for maintaining extract concentration. To protect the flasks from direct light exposure, they were wrapped in aluminum foil to prevent degradation of light-sensitive compounds. The remaining mixture and herbal extracts were stored in the refrigerator at 4 °C for 24 hours to allow further extraction of active compounds. After this period, the

extracts were filtered through Whatman® No. 91 filter paper to remove solid residues. For subsequent experiments, a 50 µg/mL solution (as a single rate) was prepared from each extract. For this experiment, the solvent was not evaporated. Instead, the concentration of each concentrated extract was determined based on its dry matter content. To do this, 1 mL of each extract was transferred into a pre-weighed microtube and dried until a constant weight was reached and all solvent was removed. The dry residue was calculated by subtracting the weight of the empty tube from the final weight, then dividing by the initial extract volume to determine concentration in µg/mL. As the initial concentration of all extracts exceeded 50 µg/mL, the required dilution factor was calculated using the standard equation $C_1V_1 = C_2V_2$, and the extracts were diluted with ethanol to achieve a final concentration of 50 µg/mL for use in the bioassays. This concentration was chosen based on previous studies indicating that this range often yields optimal results for biological assays involving plant extracts. For instance, Céspedes et al. (2014) showed that similar concentrations effectively inhibited insect activity, allowing clearer analysis of the extracts' insecticidal properties. In our preliminary experiments, we observed over 50% mortality in most treatments at this concentration of *M. azedarach* ethanolic extracts. This concentration also showed insecticidal activity against *A. fabae*.

Producing plant extracts through ultrasound-assisted extraction

This stage focused on enhancing the efficiency and quality of phytochemical extraction using ultrasound-assisted extraction techniques. Ethanol (96%) was selected as the dispersion mediator, recognized for its effectiveness in extracting a broad spectrum of phytochemicals from plant materials. Seventy grams of finely ground plant material from various growth stages were placed in a 500 mL glass container, to which ethanol was added to reach a final volume of 150 mL. The container was then placed in the UP200s ultrasonic device (Hielscher, Germany), and the water temperature was maintained between 20

and 30 °C, which is optimal for extraction, as suggested by relevant studies (Shen *et al.*, 2023).

To prevent damage to the ultrasonic equipment, the device was programmed to rest for 1 minute after 2 minutes of operation, and this cycle was repeated throughout the 45-minute extraction period for each extract. After extraction, the resulting plant extract was filtered from the residual plant material using Whatman® No. 91 filter paper. For subsequent experiments, we prepared a 50 µg/mL solution from each extract. The concentration determination and adjustment steps were performed as described in the previous experiment. The ultrasonic device operated at 80 kHz with a 0.6 duty cycle, allowing efficient extraction.

Bioassay tests

This study investigated the effects of flower extracts, various growth stages of fruit, and leaf extracts of *M. azedarach* on 1-2 days-old and 3-4 days-old nymphs of the black bean aphid. Two extraction techniques were employed: Conventional extraction and Ultrasound-assisted extraction, to evaluate their impact on the yield of extracts and their insecticidal potency. Each experimental unit comprised a 6 cm Petri dish containing 0.7% agar gel, topped with a fresh broad bean leaf, on which 20 nymphs were placed. A concentration of 50 µg/mL of each extract (single rate) was prepared for testing. Ethanol was used as the solvent for all solutions. In the witness treatments, ethanol was used as the extraction solvent, while the control group received no additional substance, allowing the aphids to grow freely. The experiments were conducted by uniformly spraying the extracts onto the aphids using a laboratory-grade glass reagent sprayer with a rubber bulb, applying a consistent volume of 5 mL per 10 Petri dishes. After treatment, the aphids were maintained under controlled conditions at 25 ± 1 °C and $50 \pm 10\%$ relative humidity, with a 16:8 (L: D) h to simulate natural conditions. After 48 hours, the number of dead insects in each treatment was counted. Mortality was confirmed when no movement was observed after gently stimulating the legs and antennae with a fine brush. For each

extract, at least 10 replications were conducted to ensure the reliability of the results.

Data analysis

To verify the basic assumptions of the data, the data were first tested for normal distribution and homogeneity of variance using the Bartlett test (Köhler *et al.*, 2002). For data that did not meet the assumptions of normal distribution, transformations were applied to achieve conformity, utilizing the Box-Cox formula:

$$Y = X^2 - 1/\lambda \text{ if } \lambda \neq 0,$$

$$Y = \ln X \text{ if } \lambda = 0,$$

Where: Y – the transformed value, X – the untransformed value, and $0 < \lambda < 1$ (Anonymous, 1996).

Statistical analyses for the experiments conducted in this study were performed using Stat Plus (Version 5.8.4, 2009). To compare data from the in vitro studies, One-Way ANOVA with Fisher's Least Significant Difference (LSD) test was utilized.

Results

Insecticidal effects of ethanolic extract from conventional extraction

The insecticidal effects of ethanolic extracts from five growth stages of Persian lilac (*M. azedarach*) on 1-2 days-old and 3-4 days-old nymphs of black bean aphids (*A. fabae*) are summarized in Figure 1.

1-2 days-old nymphs:

Results indicate no significant differences in mortality rates among the ethanolic extracts of flower, small green fruit, big green fruit, ripe fruit, and leaf. However, ethanol showed a significant difference in mortality percentage compared with extracts from all five growth stages ($P \geq 0.002$). Although the leaf extract produced the highest average mortality rate ($65.24 \pm 5.89\%$) and the large green fruit extract the lowest ($51.19 \pm 7.04\%$), the difference between the two was not statistically significant.

3-4 days-old nymphs:

In this age group, mortality percentages in the control and ethanol treatments differed significantly from all extracts ($P \geq 0.00001$). Additionally, the small green fruit and big green

fruit extracts showed significant differences in mortality rates when compared to the flower, ripe fruit, and leaf extracts ($P \geq 0.02$). Furthermore, significant differences were found between the small green fruit and big green fruit extracts, as well as among the flower, small green fruit, and big green fruit extracts regarding their insecticidal efficacy on 3-4-day-old nymphs ($P \geq 0.00001$). However, the flower extract did not differ significantly from the ripe fruit and leaf extracts. Moreover, a significant difference in mortality rates was observed between the leaf extract and all other extracts, except for the flower extract ($P \geq 0.02$). Similarly, the mortality rate of the ripe fruit extract was significantly different from all extracts, except for the flower extract ($P \geq 0.004$). Overall, the ripe fruit extract demonstrated the highest mortality percentage among the plant extracts at $88.5 \pm 2.79\%$, while the small green fruit extract exhibited the lowest mortality percentage at $31.83 \pm 4.17\%$.

Insecticidal effects of ethanolic extract from ultrasound-assisted extraction

1-2 Day-Old Nymphs: The findings (Fig. 2) indicate a statistically significant difference in mortality rates between the control and ethanol treatments ($P \geq 0.0001$). Moreover, mortality rates in these treatments were significantly lower than those of extracts from all five growth stages (flower, small green fruit, big green fruit, ripe fruit, and leaf) ($P \geq 0.00001$). Notably, a significant difference was also observed between the mortality percentages of the big green fruit and leaf extracts ($P \geq 0.02$). However, no significant differences were detected among the insecticidal effects of the flower, small green fruit, and ripe fruit extracts, nor when compared to the leaf and big green fruit extracts. Overall, the leaf extract showed the highest mortality rate ($98.0 \pm 1.33\%$), while the big green fruit extract showed the lowest ($87.5 \pm 4.61\%$).

3-4 Day-Old Nymphs: Similar trends were observed in this age group, with a significant difference in mortality percentages between the control and ethanol treatments ($P \geq 0.0001$). Ethanolic extracts from all five growth stages of *M. azedarach* showed significantly higher

mortality rates than both the control and ethanol treatments ($P \geq 0.00001$). However, the mortality rates among these five extracts did not differ significantly. Among the extracts, the leaf

extract again showed the highest insecticidal efficacy, with a mortality percentage of $96.9 \pm 1.30\%$, while the small green fruit extract showed the lowest efficacy at $86.8 \pm 4.72\%$.

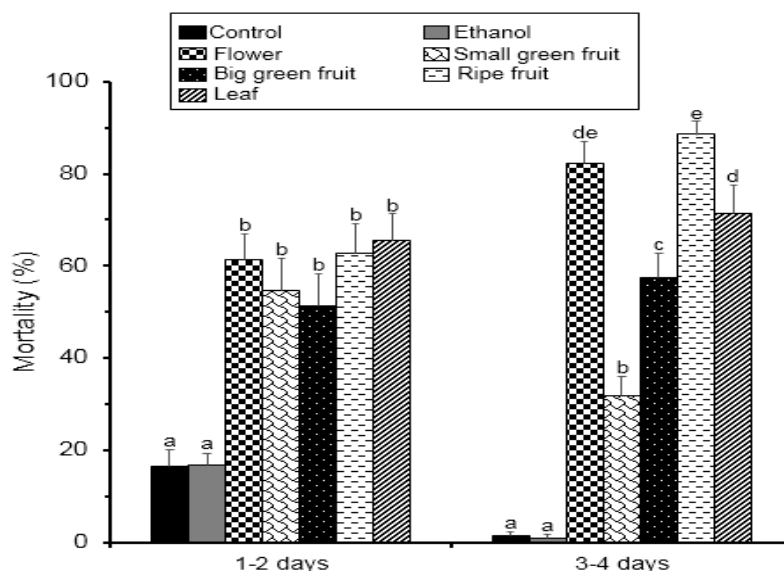


Figure 1 Effect of ethanolic extracts from conventional extraction from flowers, various growth stages of fruits, and leaves of *Melia azedarach* on 1-2 days old and 3-4 days old nymphs of *Aphis fabae* under laboratory conditions. Means with the same letters are not significantly different (LSD test, $P \leq 0.05$).

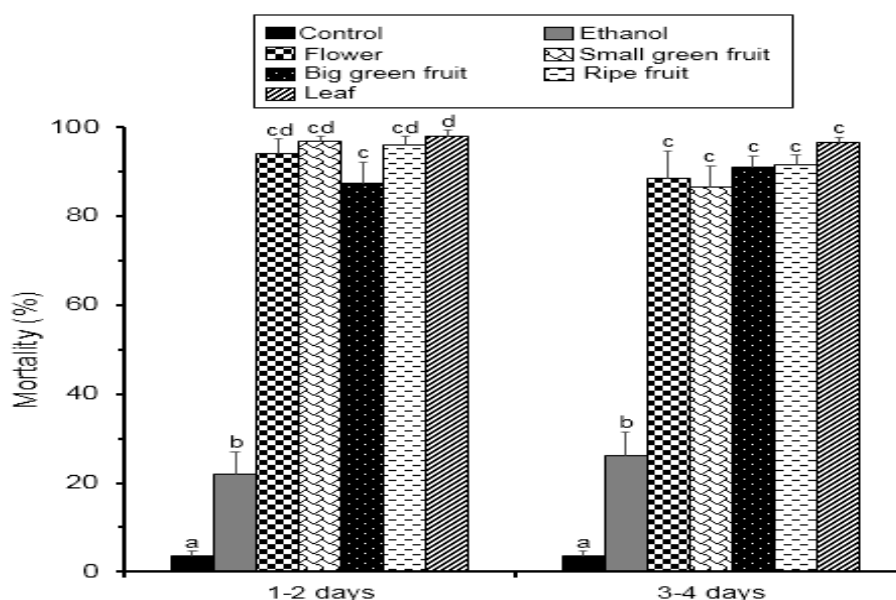


Figure 2 Effect of ethanolic extracts obtained through Ultrasound-Assisted Extraction (UAE) from flowers, various growth stages of fruits, and leaves of *Melia azedarach* on 1-2-day-old and 3-4-day-old nymphs of *Aphis fabae* under laboratory conditions. Means with the same letters are not significantly different (LSD test, $P \leq 0.05$).

Comparison of insecticidal effects from two extraction methods

To enable a more accurate comparison of the mean mortality rates of *A. fabae* caused by extracts obtained through two different methods, and to assess mortality across various developmental stages of the aphids, the data are presented in Figure 3. The results indicate that,

except in two cases, extracts obtained using the ultrasound-assisted extraction method (UAE) significantly increased mortality rates compared with the conventional extraction method (CEE) ($P \geq 0.0001$). Additionally, mortality rates caused by the same extract across different aphid developmental stages showed no significant differences, except in one case.

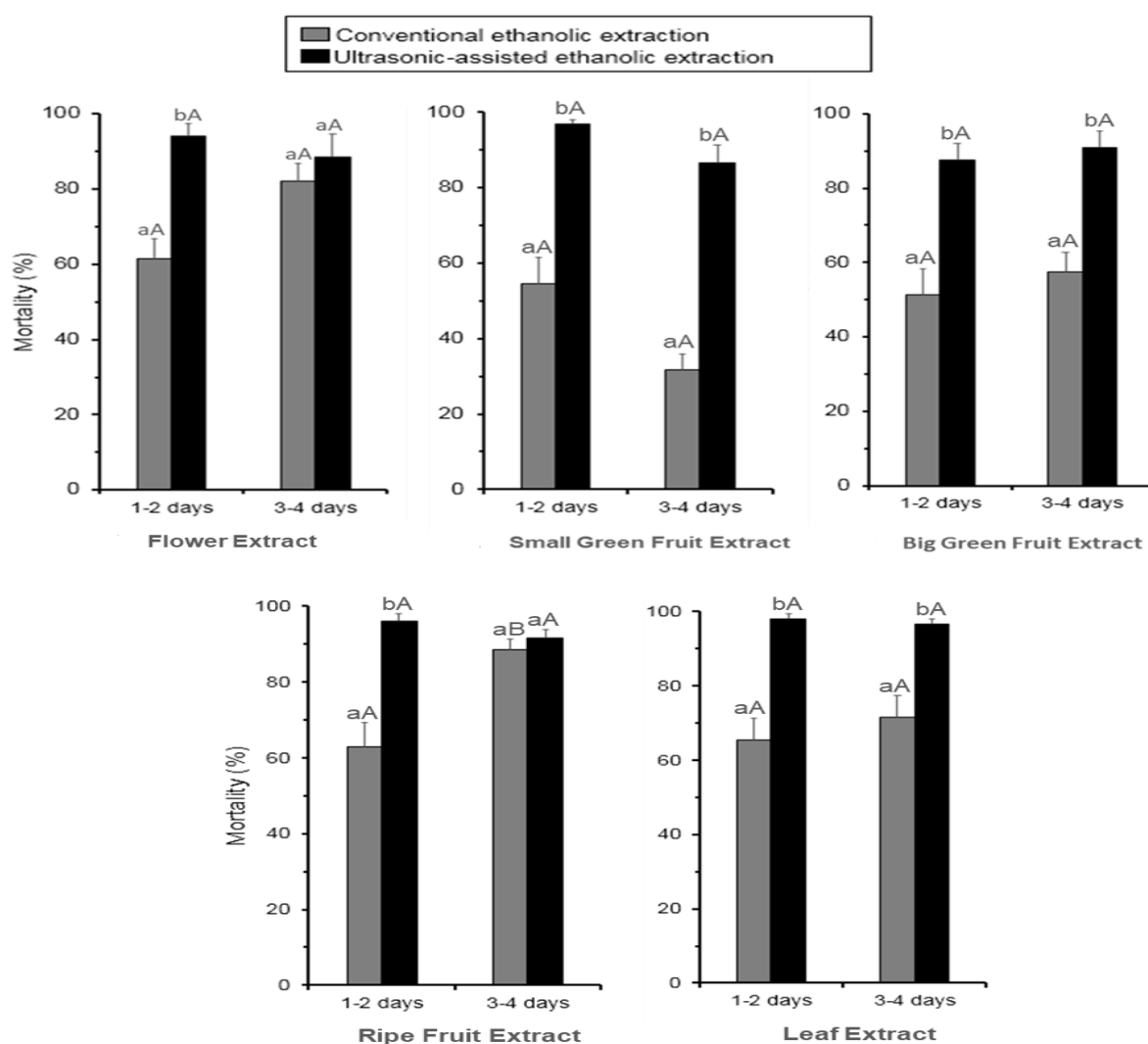


Figure 3 Insecticidal effects of ethanolic extracts from flowers, various growth stages of fruits, and leaves of *Melia azedarach* obtained by Conventional Ethanolic Extraction (CEE) and Ultrasound-Assisted Ethanolic Extraction (UAE) methods on 1-2-day-old and 3-4-day-old nymphs of *Aphis fabae* under laboratory conditions. Bars labeled with different lowercase letters indicate significant differences among the extraction methods within the same developmental stage. In contrast, bars labeled with different uppercase letters indicate significant differences between developmental stages within the same extraction method (LSD test, $P \leq 0.05$).

Discussion

This study investigated the insecticidal effects of ethanolic extracts (Conventional Extraction) from different growth stages of *M. azedarach* on *A. fabae* nymphs. In 1-2-day-old nymphs, mortality rates among the extracts were similar, but ethanol showed significantly lower mortality, aligning with Tavares et al. (2021) on the impact of extraction solvents on insecticidal potency. In contrast, in 3-4-day-old nymphs, significant differences were observed, with the ripe fruit extract showing the highest mortality rate ($88.5 \pm 2.79\%$). These results do not align with the findings of Indriyani et al. (2023), which suggest that immature plant parts typically contain higher levels of bioactive compounds. In ripe fruits, there may be higher levels of active compounds that exhibit insecticidal properties. This may be due to metabolic changes during different growth stages and the accumulation of specific compounds in mature fruits. Studies suggest that compounds like flavonoids and terpenoids, known for their insecticidal effects, may vary in concentration throughout the plant's development (Roy et al., 2022). The leaf extract also exhibited considerable efficacy, supporting the findings of Afzal et al. (2024). The lower mortality rate of the small green fruit extract suggests that extract efficacy varies with developmental stage. Overall, the findings highlight the importance of both extraction methods and plant growth stages in determining insecticidal efficacy and emphasize the need for further research to identify specific bioactive compounds responsible for these effects.

The significant increase in mortality rates observed with the Ultrasound-Assisted Extraction (UAE) method aligns with findings from other studies showing UAE's enhanced efficiency in extracting bioactive compounds with insecticidal properties (Chemat et al., 2017; Gil-Martín et al., 2022; Wu et al., 2022). This enhanced release likely contributes to the higher mortality rates observed compared with the conventional extraction method (CEE).

Moreover, UAE's capability to maintain the stability and potency of bioactive compounds during extraction (Shen et al., 2023) might explain its higher efficacy in inducing aphid mortality. However, despite these findings, mortality rates across different developmental stages of *A. fabae* did not differ significantly, suggesting that these stages are equally susceptible to the active components in the extracts. This uniformity may be attributed to the general mechanism of action of the compounds, which likely disrupts essential physiological processes, such as respiration or cellular metabolism, affecting all developmental stages (Lengai et al., 2020).

These results underscore UAE as a promising method for obtaining potent insecticidal extracts and offer advantages over traditional extraction methods. Future research should further explore optimizing UAE parameters to maximize insecticidal efficacy and assess long-term impacts on aphid populations across different environmental conditions.

References

- Afzal, M., Rehman, H.-U., Zeb, I. and Qureshi, N. A. 2024. Efficacy of *Melia azedarach* leaf extract in different solvents against *Heterotermes indicola* Wasmann (Blattodea: Rhinotermitidae) using non-durable wooden blocks under laboratory and field conditions. South African Journal of Botany, 174:747-754. Available from: doi:10.1016/j.sajb.2024.09.064.
- Anonymous, 1996. Reference manual of the statistics program for Windows Winstat. Kalmia Company Inc., Cambridge, MA, 267 pp.
- Bitwell, C., Indra, S. S., Luke, C. and Kakoma, M. K. 2023. A review of modern and conventional extraction techniques and their applications for extracting phytochemicals from plants. Scientific African, 19: e01585. Available from: doi:10.1016/j.sciaf.2023.e01585.
- Blackman, R. L. and Eastop, V. F. 2007. Taxonomic issues. In: Emden, H.F.V. and Harrington, R. (Eds.) Aphids as Crop Pests.

- CABI, Wallingford, UK. Available from: doi:10.1079/9780851998190.0001.
- Céspedes, C. L., Salazar, J. R., Ariza-Castolo, A., Yamaguchi, L., Ávila, J. G., Aqueveque, P., Kubo, I. and Alarcón, J. 2014. Biopesticides from plants: *Calceolaria integrifolia* s.l. Environmental Research, 132: 391-406. Available from: doi:10.1016/j.envres.2014.04.003.
- Chemat, F., Rombaut, N., Sicaire, A.-G., Meullemiestre, A., Fabiano-Tixier, A.-S. and Abert-Vian, M. 2017. Ultrasound assisted extraction of food and natural products. Mechanisms, techniques, combinations, protocols and applications: A review. Ultrasonics Sonochemistry, 34: 540-560. Available from: doi:10.1016/j.ultsonch.2016.06.035.
- Dadang, D., Fitriyari, E. D. and Prijono, D. 2009. Effectiveness of two botanical insecticide formulations against two major cabbage insect pests in field applications. J. Issaas, 1: 42-51.
- Deshmukh, P. B. and Renapurkar, D. M. 1987. Insect growth regulatory activity of some indigenous plant extracts. Insect Science and Its Application, 8(1): 81-83. Available from: doi:10.1017/S1742758400007013.
- Gil-Martín, E., Forbes-Hernández, T., Romero, A., Cianciosi, D., Giampieri, F. and Battino, M. 2022. Influence of the extraction method on the recovery of bioactive phenolic compounds from food industry by-products. Food Chemistry, 378: 131918. Available from: doi:10.1016/j.foodchem.2021.131918.
- Hardin, M. R., Benrey, B., Coll, M., Lamp, W. O., Roderick, G. K. and Barbosa, P. 1995. Arthropod pest resurgence: An overview of potential mechanisms. Crop Protection, 14:1-3.
- Hodjat, A. 1986. The biology, host plants and sub-species of *Aphis fabae* in Iran. In: Ebadi, R. (ed.), Proceedings of the 8th Iranian Plant Protection Congress, Isfahan University of Technology, Isfahan, Iran, pp. 5.
- Hoffmann, K. H. and Lorenz, M. W. 1998. Recent advances in hormones in insect pest control. Phytoparasitica, 26: 323-330.
- Indriyani, N. N., Anshori, J. A., Permadi, N., Nurjanah, S. and Julaeha, E. 2023. Bioactive components and their activities from different parts of *Citrus aurantifolia* (Christm.) Swingle for food development. Foods, 12: 2036. Available from: doi:10.3390/foods12102036.
- Isman, M. B., Matsuura, H., MacKinnon, S., Durst, T., Towers, G. H. N. and Arnason, J. T. 1996. Phytochemistry of the Meliaceae. In: Romeo, J. T., Saunders, J. A. and Barbosa, P. (eds) Phytochemical Diversity and Redundancy in Ecological Interactions. Recent Advances in Phytochemistry, vol 30. Springer, Boston, MA. Available from: doi:10.1007/978-1-4899-1754-6_6.
- Köhler, W., Schachtel, W. and Voleske, P. 2002. Biostatistik. Springer-Verlag, Berlin, 301 pp.
- Lee, M., Klocke, J. A., Barnby, M. A. and Yamasaki, R. B. 1991. Pesticidal constituents of *Azadirachta indica* and *Melia azedarach* (Meliaceae). In: Hedin, P. (ed.), Naturally Occurring Pest Bioregulators, American Society, pp. 293-304. Available from: doi:10.1021/bk-1991-0449.ch019.
- Lengai, G. M. W., Muthomi, J. W. and Mbega, E. R. 2020. Phytochemical activity and role of botanical pesticides in pest management for sustainable agricultural crop production. Scientific African, 7: e00239. Available from: doi:10.1016/j.sciaf.2019.e00239.
- Longley, M., Jepson, P.C., Izquierdo, J. and Sotherton, N. 1997. Temporal and spatial changes in aphid and parasitoid populations following applications of deltamethrin in winter wheat. Entomologia Experimentalis et Applicata, 83: 41-52. Available from: doi:10.1046/j.1570-7458.1997.00155.x.
- Nicoletti, M. 2020. Chapter seven - New solutions using natural products. In: Nicoletti, M. (Ed.), Insect-borne diseases in the 21st century, pp. 263-351. Academic Press. Available from: doi:10.1016/B978-0-12-818706-7.00007-3.
- Roy, A., Khan, A., Ahmad, I., Alghamdi, S., Rajab, B. S., Babalghith, A. O., Alshahrani, M. Y., Islam, S. and Islam, M. R. 2022. Flavonoids: A bioactive compound from

- medicinal plants and its therapeutic applications. Biomed Research International: 5445291. Available from: doi:10.1155/2022/5445291.
- Schepers, A. 1989. Control of aphids. In: Minks, A. K. and Harrewijn, P. (Eds.), *Aphids: Their biology, natural enemies and control*, Volume C. Elsevier Science Publishers, pp. 89-122.
- Schmutterer, H. 1989. Biologically active compounds from Meliaceae. *Pesticide Science*, 27(2): 189-199.
- Shen, L., Pang, S., Zhong, M., Sun, Y., Qayum, A., Liu, Y., Rashid, A., Xu, B., Liang, Q., Ma, H. and Ren, X. 2023. A comprehensive review of ultrasonic assisted extraction (UAE) for bioactive components: Principles, advantages, equipment, and combined technologies. *Ultrasonics Sonochemistry*, 101: 106646. Available from: doi:10.1016/j.ultsonch.2023.106646.
- Shotipruk, A., Kaufman, P. B. and Wang, H. Y. 2001. Feasibility study of repeated harvesting of menthol from biologically viable *Mentha x piperata* using ultrasonic extraction. *Biotechnology Progress*, 17(5): 924-928. Available from: doi:10.1021/bp010074u.
- Tavares, W. R., Barreto, Md. C. and Seca, A. M. L. 2021. Aqueous and ethanolic plant extracts as bio-insecticides—establishing a bridge between raw scientific data and practical reality. *Plants*, 10(5): 920. Available from: doi:10.3390/plants10050920.
- Valladares, G., Defago, M. T., Palacios, S. and Carpinella, M. C. 1997. Laboratory evaluation of *Melia azedarach* (Meliaceae) extracts against the elm leaf beetle (Coleoptera: Chrysomelidae). *Journal of Economic Entomology*, 90(3): 747-750. Available from: doi:10.1093/jee/90.3.747.
- Vilkhu, K., Mawson, R., Simons, L. and Bates, D. 2008. Applications and opportunities for ultrasound-assisted extraction in the food industry — A review. *Innovative Food Science and Emerging Technologies*, 9(2): 161-169. Available from: doi:10.1016/j.ifset.2007.04.014.
- Vinatoru, M. 2001. An overview of the ultrasonically assisted extraction of bioactive principles from herbs. *Ultrasonics Sonochemistry*, 8(3): 303-313. doi:10.1016/S1350-4177(01)00071-2.
- Wu, Y., Yao, S., Narale, B. A., Shanmugam, A., Mettu, S. and Ashokkumar, M. 2022. Ultrasonic processing of food waste to generate value-added products. *Foods*, 11(14): 2035. Available from: doi:10.3390/foods11142035.
- Zhang, L., Zhou, C., Wang, B., Yagoub, A. E.-G.A., Ma, H., Zhang, X. and Wu, M. 2017. Study of ultrasonic cavitation during extraction of the peanut oil at varying frequencies. *Ultrasonics Sonochemistry*, 37: 106-113. Available from: doi:10.1016/j.ultsonch.2016.12.034.

مقایسه کارایی حشره‌کشی عصاره‌های اتانولی رایج و به‌کمک امواج فراصوت از مراحل مختلف رشدی *Melia azedarach* بر مرگومیر پوره‌های *Aphis fabae*

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چکیده: اثر حشره‌کشی عصاره اتانولی رایج (Conventional Ethanollic Extract; CEE) تهیه شده از پنج مرحله رشدی زیتون تلخ، *Melia azedarach*، شامل گل، میوه سبز کوچک، میوه سبز بزرگ، میوه رسیده و برگ، بر پوره‌های شته سیاه باقلا، *Aphis fabae* مورد بررسی قرار گرفت. در پوره‌های ۱ تا ۲ روزه، تفاوت معنی‌داری در میزان مرگومیر بین عصاره‌ها مشاهده نشد و عصاره برگ با 5.89 ± 5.24 درصد، بیش‌ترین میزان مرگومیر را نشان داد. در پوره‌های ۳ تا ۴ روزه، عصاره میوه رسیده با $2.79 \pm 8.8/5$ درصد بیش‌ترین میزان مرگومیر را داشت، درحالی‌که عصاره میوه سبز کوچک با 4.17 ± 31.83 درصد کمترین میزان مرگومیر را نشان داد. همچنین، اثرات حشره‌کشی عصاره‌های اتانولی حاصل از پنج مرحله رشدی زیتون تلخ با استفاده از استخراج به‌کمک امواج فراصوت (Ultrasound-Assisted Extraction; UAE) مورد بررسی قرار گرفت. در پوره‌های ۱ تا ۲ روزه، تفاوت معنی‌داری بین تیمار شاهد و تیمار اتانول مشاهده شد ($P \geq 0.0001$) و میزان مرگومیر در این دو تیمار کمتر از عصاره‌ها بود ($P \geq 0.00001$). عصاره برگ با 1.33 ± 98.0 درصد، بیش‌ترین میزان مرگومیر را به ثبت رساند، درحالی‌که عصاره میوه سبز بزرگ با 4.61 ± 87.5 درصد کمترین میزان مرگومیر را نشان داد. در پوره‌های ۳ تا ۴ روزه نیز نتایج مشابه یافته‌های قبلی بود و تفاوت‌های معنی‌داری مشاهده شد ($P \geq 0.0001$)؛ به‌طوری‌که عصاره‌ها میزان مرگومیر بیش‌تری ایجاد کردند ($P \geq 0.00001$). در این مرحله نیز عصاره برگ با 1.30 ± 96.9 درصد بیش‌ترین اثر حشره‌کشی را داشت، درحالی‌که عصاره میوه سبز کوچک با 4.72 ± 86.8 درصد کمترین میزان اثرگذاری را نشان داد. در مقایسه اثرات حشره‌کشی عصاره‌های اتانولی حاصل از دو روش CEE و UAE بر شته سیاه باقلا، داده‌ها نشان دادند که، به‌جز در دو مورد، استفاده از روش UAE در مقایسه با CEE به‌طور معنی‌داری موجب افزایش میزان مرگومیر شد ($P \geq 0.0001$).

واژگان کلیدی: حشره‌کش‌های گیاهی، استخراج اتانولی رایج (CEE)، استخراج به‌کمک امواج فراصوت (UAE)، مرگومیر، شته سیاه باقلا