NATURAL AND ALTERNATIVE METHODS AGAINST VARROA DESTRUCTOR

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ABSTRACT

Varroa destructor is one of the most important problems of bee breeding in the world and is the most important honey bee parasite that negatively affects the productivity and health of honey bees worldwide. Varroa causes great damage to honey bee colonies by sucking the hemolymph of honey bees. Many studies have been conducted to eliminate the harmful effects of the varroa parasite, and genetic, chemical, mechanical, and biological control methods have been developed. It is extremely important to control varroa in all bee products, especially honey and beeswax, without leaving harmful residues to honey bees and human health. For this reason, natural and alternative methods are becoming more important than chemicals in varroa control.

Anahtar Kelimeler: *Varroa destructor, essentıal oils, plant extracts, biological control*

VARROA DESTRUCTOR'A KARŞI DOĞAL VE ALTERNATİF YÖNTEMLER

ÖZET

Varroa Destructor, Dünya'da arı yetiştiriciliğinin en önemli sorunlarından birisi olup bal arılarının verimliliğini ve sağlığını dünya çapında olumsuz etkileyen en önemli bal arısı parazitidir. Varroa, bal arılarının hemolenfini emerek bal arısı kolonilerine büyük zararlar vermektedir. Varroa parazitinin zararlı etkilerini ortadan kaldırmak için birçok çalışma yapılmıştır ve genetik, kimyasal, mekanik ve biyolojik mücadele yöntemleri geliştirilmiştir. Bal ve balmumu başta olmak üzere tüm arı ürünlerinde bal arıları ve insan sağlığına zararlı olacak kalıntılar bırakmadan varroaya karşı mücadele etmek son derecede önemlidir. Bu nedenle varroa mücadelesinde kimyasal kullanımının yerine doğal ve alternatif yöntemler giderek önem kazanmaktadır.

Keywords: *Varroa destructor, uçucu yağlar, bitki ekstraktları, biyolojik kontrol*

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1. INTRODUCTION

Varroa destructor is an extremely harmful external parasite that lives in the larval, pupal, and adult stages of honey bees and feeds by sucking their blood fluid called hemolymph and can multiply in colonies for a long time without being noticed. Varroa can persist at all stages of the bee's development. Mated adult female varroa spend the winter on the bees. During this period the bees gather tightly together in the hive to form a winter cluster. When spring comes, the queen bee starts laying eggs in the comb cells. The worker bees close the comb cells containing the larvae in about 5-6 days. Varroa enters the honeycombs just before the worker bees close the combs and feeds easily in the closed combs, because the worker bees cannot interfere with the closed comb. Varroa usually prefers the honeycomb cells of drones because they are larger, drones have a longer developmental period than others, and drone cells on the sides of the comb are cooler. These conditions are extremely favorable for Varroa to breed. (Sammataro et al., 2000; Rosenkranz, et al., 2010)

Varroatosis caused by the ectoparasitic mite *Varroa destructor* is one of the biggest problems for honey bees (*Apis mellifera*) and beekeeping worldwide. The disease causes reduced growth rate of colonies, winter loss in honey bees, reduced flight activity, reduced nectar and pollen collection capacity, body deformations, and body weight loss in adult bees. In the advanced stages of the disease, V. destructor causes the destruction of colonies by damaging honey bees (Anderson & Trueman, 2000; Amdam, et al., 2004). This parasite is also a carrier of different pathogenic microorganisms. Varroa mite is especially responsible for honey bee viruses such as Deformed Wing Virus (DWV) (Posada-Flore et al., 2020), Acute Bee Paralysis Virus (ABPV) (Erban, et al., 2015), Vesiculovirus (SBV) (Drescher, et al., 2017), Kashmir Bee Virus (KBV) (Shen, et al, 2005) and Israeli Acute Paralysis Virus (IAPV) (de Miranda, et al., 2010), Black Queen Cell Virus (BQCV) (Karapınar et al., 2018) and these diseases cause great losses in colonies.

The fact that honey bees are among the most important pollinators in the world, the usage areas of honey bee products, and economic factors (Rucker et al., 2012) reveal the importance of varroa control. Varroa control is mandatory for honey bee colonies to survive and for breeders to continue beekeeping. Chemical, biological, genetic, and hormonal control methods have been used against *V. destructor* in various countries (Anderson & Trueman, 2000; Gregorc & Planinc, 2002; Garbian et al., 2012).

One of the most common methods of controlling Varroa is using chemical compounds. While chemical treatments provide fast and effective control of the parasite, they also carry many risks. Commonly used licensed chemical drugs include Folbex-VA®, Formic Acid plates®, Perizin®, Antivarroa®, Apitol®, Apistan®, Bayvarol®, Varropol®. These synthetic acaricides contain active ingredients such as amitraz, flumetrin, promopropylate, and coumaphos. The point to be considered in chemical control is the appropriate dose and correct timing. Since varroa hiding in closed pupal eyes will not be affected by the drugs, chemical treatment should be carried out especially in periods when pupal production is less. Rotation with different active ingredients in chemical treatment is an important point to prevent the development of resistance of Varroa (Ellis & Hayes, 2009; Haber & vanEngelsdorp, 2019; Turhan, 2024).

2. Biological Control

Biological control of varroa is an environmentally approach that aims to manage pest mite populations through natural processes and organisms. Biological control is emerging as an effective alternative to minimize the long-term negative effects of chemical acaricides and avoid resistance problems. One of the most remarkable of these methods is the use of entomopathogenic fungi targeting Varroa mites. For example, fungal species such as *Metarhizium anisopliae* and *Beauveria bassiana* penetrate the exoskeleton of the mites, infecting and killing them. In order to apply these fungi effectively, it is important to ensure suitable environmental conditions and to manage them in a way that does not harm bee colonies (García-Fernández et al., 2008).

The development of genetically resistant honey bees is an important part of the biological control mechanism. The strategy here is to select bees with Varroa Sensitive Hygiene (VSH) traits and use them in beekeeping activities. These bees control the presence of varroa in the colony by cleaning the honeycombs infected with varroa (Danka et al., 2011).

Pheromone-based applications are alternative methods to chemicals in the control of varroa. Although studies on the subject are limited, this method aims to control the behavior of varroa by means of different pheromones (Park et al., 2023).

Organic acids are a powerful alternative to using chemicals in varroa control. Organic acids are a reliable method against varroa mites. When organic acids are used appropriately, they offer the opportunity to control varroa without threatening honey bees and human health. Organic acids such as oxalic acid, formic acid, and lactic acid are especially effective against varroa. Organic acids work by having a toxic effect on the respiratory system of the varroa mite (Imdorf et al., 1996; Rosenkranz et al., 2010). Oxalic acid is especially effective in the fall and early winter months as it affects varroa on adult bees. Oxalic acid used at appropriate doses during these periods has maximum effect (Gregorc & Planinc, 2002). Formic acid is mostly applied by evaporation due to its evaporation property. It is effective on varroa in open and closed pupal eyes. It is recommended to be used in periods when the number of brood is low. The most important consideration in using formic acid is the ambient temperature. At high temperatures, the high level of formic acid evaporation can cause damage to honey bees, while at low temperatures, the level of effectiveness will not be sufficient (Satta et al., 2005). Lactic acid is not preferred because it requires frequent use and creates a workload. Akyol & Özkök, 2005).

Colony or hive management interventions can be an effective way of controlling Varroa mite populations. More successful results can be obtained when these interventions are applied together. Mechanical control methods include the use of sieved floorboards, limiting drone brood production, removing drone brood from the colony, trapping in drone cells, limiting drone brood production, using young queens and sprinkling powdered sugar (Akyol & Korkmaz, 2006; Muz et al., 2014; Devi et al., 2019).

3. Use Of Plant Extracts And Essential Oils In Varroa Control

The use of natural and alternative methods instead of chemicals in varroa control is very important for both honey bees and human health. Plant extracts and essential oils have gained importance both because they are effective in controlling varroa mites and because they are alternatives to chemical acaricides. Especially essential oils such as thymol, linalool, eugenol, carvacrol, and eugenol can reduce their populations by affecting the physiological and behavioral processes of mites (Imdorf et al., 1999). Plant extracts are a promising tool in varroa control thanks to their antimicrobial and antiparasitic properties (Islam et al., 2016).

Studies have shown that essential oils obtained from aromatic plants such as tobacco, pine leaves, garlic, thyme, eucalyptus, juniper, mint, flea grass, walnut, citrus, sage, etc., show 45-70% efficacy against varroa (Imdorf & Charriere, 2002). Tobacco smoke was found to be 65-95% effective against varroa (Bakandritsons & Zabunis, 1985). Delaphane (1992) reported that menthol in mint and Shaarawi (1995) reported that mint, wormwood and eucalyptus are effective in the control of Varroa.

El-Wahab & Ebada (2006), used in their examination different concentrations of *Cymbopagon flexuosus* (Lemon grass), *Citrus aurantium* L (Sour Orange), and *Citronella volatile* oils varroa mites in honey bee colonies. The mean percentage of varroa infestation on the worker brood and adult workers reduced to 100% after the fourth week of treatment with *Citrus aurantium L*, *Cymbopagon flexuosus*, and after the third week of treatment with *Citronella oils*.

Damiani et al. (2009) examined the acaricidal properties of essential oils obtained from Thymus vulgaris, Laurus nobilis, Lavandula officinalis, and Lavandula hybrida. These oils, which contain linalool, 1,8-Cineole, and thymol as their primary components, were found to effectively cause mortality in Varroa destructor mites. Importantly, none of the essential oils tested caused significant harm to adult bees.

Çakmak et al. (2006) tested pollen traps, in conjunction with walnut leaf smoke or mint leaves, as a control for *V. destructor*. All treatments with pollen traps reduced the mite population by approximately 50%; the treatment without pollen traps reduced the mite population significantly more.

Çetin (2010) suggested the use of eucalyptus bark and leaves, oxalic acid, lactic acid, worker bee removal, orange peel, and drone bee removal as effective methods for combating Varroa. These approaches were proposed as practical solutions for beekeepers to implement in their efforts against the parasite..

Rafaei (2010) tested Apiguard and Thyme, Camphor, and Basil oils as control agents against V. destructor. Data showed that all four tested compounds effectively controlled Varroa and Apiguard was the most effective substance.

In a study evaluating the biological activity of herbal extracts from *Baccharis flabellata* and *M. verticillata* on V. destructor and *A. mellifera*, it was determined that these plant extracts did not harm honey bees and showed toxic effect on varroa (Damiani et al., 2011).

Abd El-Wahab et al. (2012) investigated the effects of formic acid and thyme, cinnamon, anise and lemongrass oil applications on Varroa development and grooming behavior of honey bees and found that high dose applications of formic acid and essential oils had a significant effect on Varroa. In the study, it was determined that thyme oil was the most effective substance on Varroa deformation, which was examined as a grooming behavior parameter.

Qayyoum et al. (2013) said that in their study, plant extracts, Neem oil, Mixture (Neem oil, garlic oil, and tobacco oil), and tobacco oil have obtained hopeful results. The percentage of mixture infestation is more effective in all categories. Mixture also plays a vital role in the % reduction of mites from broods, while neem oil in % reduction of bees.

Islam et al. (2016), was examined four essential oils of Thyme, Lemon grass, Rosemary, Mint, and Formic Acid (65%) used at three concentrations (25, 50, and 100%) against Varroa destructor. They determined the percentage of infestation by varroa destructor on adult workers and worker brood, percent mite mortality and their honey, and number of dead fallen Varroa yield before and after the treatments in the experimental colonies. The results of their research showed that 100% concentrations of tested essential oils and the formic acid caused important control of Varroa, whereas the invasion reduction percentage with formic acid, lemon grass, thyme, mint, and rosemary oils was recorded at more than 96% after the end of treatments on both adult workers and worker brood.

Stanimirović et al. (2017) conducted a field trial to evaluate the varroacidal efficacy of a plant-based formulation called Argus Ras. This formulation included extracts from *Sophora flavescens*, *Ginkgo biloba*, *Gleditsia chinensis*, and *Teucrium chamaedrys*. The study involved 240 *Apis mellifera* colonies, and the effectiveness of Argus Ras was assessed in combination with amitraz and oxalic acid. The results showed that Argus Ras achieved an average acaricidal efficacy of 80.89%, surpassing the effectiveness of other previously tested essential oils.

Costic acid has been isolated from the plant *Dittrichia viscosa* and its efficacy against varroa, a parasite studied by Sofou et al. (2017). They determined costic acid exhibited potent in vivo acaricidal activity against the parasite.

In their study, Tsegaye et al. (2024) investigated the effects of smoke from *Cordia Africana*, *Terminallia*, tobacco, and a mixture of barley and *Olea* leaves on *Varroa* control. They found that tobacco leaf smoke and *Terminallia* leaf smoke were particularly effective in managing *Varroa destructor*. Similarly, Raza et al. (2024) examined the efficacy of essential oils extracted from *Salvia officinalis* (sage), *Cannabis sativa* (hemp), and *Laurus nobilis* (laurel) against *Varroa*. Among these, hemp oil demonstrated the highest effectiveness, while laurel oil was the least effective. Additionally, Alsaadi et al. (2024) reported that bitter melon oil could be used as an environmentally friendly and bee-safe option for controlling varroa mites.

4. CONCLUSION

As a result of the unconscious use of acaricides used in the fight against Varroa, the parasite gradually develops immunity against such drugs (Boecking and Spivak, 1999). Drugs used against varroa and synthetic acaricides leave high amounts of residues in honey and wax, causing economic problems for beekeepers (Wehling et al., 2003). While these chemicals are generally preferred due to their high efficacy, it has been observed that varroa develop resistance to these substances in cases of misuse or overuse. This leads to a decrease in treatment efficacy and complicates future control methods. In addition, the accumulation of residues in bee products (honey, beeswax, etc.) during chemical treatments is a major concern for consumer safety and bee health. Studies have shown that especially synthetic acaricides can remain in wax for a long time and may adversely affect the hive environment (Bogdanov et al., 2004). Therefore, there has been increased interest in alternatives such as organic acids and essential oils that do not endanger honey bees and human health (Rosenkranz et al., 2010).

Biological control methods are gaining attention as a more sustainable alternative to chemical treatments. Innovative strategies such as entomopathogenic fungi, genetic resistance and pheromones allow beekeepers to maintain bee health and minimize environmental impacts. The effectiveness of these approaches can be further improved through additional research and practical application experience. In the fight against Varroa, organic acids offer an environmentally friendly and effective solution. Increasing resistance to chemical acaricides and consumer demand for organic honey production are increasing interest in these natural methods. However, proper timing, correct dosage, and environmental factors need to be considered for the successful application of organic acids. Accordingly, organic acids are considered as an important component of integrated pest management (IPM) strategies (Jack & Ellis, 2021; Vilarem et al., 2021).

Plant extracts and essential oils show efficacy with minimal toxicity to honey bees and greatly reduce residue problems. The most widely used thymol-based products have been used successfully for many years in varroa control and offer advantages in terms of low cost and easy applicability. However, the effective use of plant extracts and essential oils depends on variables such as concentration, application method and environmental factors. Further investigation of the efficacy of these natural products and their potential impact on bee health is required for wider adoption of these interventions.

REFERENCES

Abd El-Wahab, T. E., & Ebada, M. A. (2006). Evaluation of some volatile plant oils and Mavrik against Varroa destructor in honey bee colonies. *J. Appl. Sci. Res*, *2*(8), 514-521.

Abd El-Wahab, T. E., Ebadah, I. M. A., & Zidan, E. W. (2012). Control of Varroa mite by essential oils and formic acid with their effects on grooming behaviour of honey bee colonies. *J. Basic. Appl. Sci. Res*, *2*(8), 7674-7680.

Akyol, E., & Korkmaz, A. (2006). Varroa destructor'un biyolojik kontrol yöntemleri. Uludağ Arıcılık Dergisi, 6(2), 62-67.

Akyol, E., & Özkök, D. (2005). Varroa (Varroa destructor) mücadelesinde organik asitlerin kullanımı. *Uludağ Arıcılık Dergisi*, *5*(4), 167-174.

Alsaadi, M., Keshlaf, M. M., & Mirwan, H. B. (2024). Some essential oils as potential control agents for varroa mite (Varroa destructor) in infected honey bees (Apis mellifera). *Open Veterinary Journal*, *14*(2), 692.

Amdam, G. V., Hartfelder, K., Norberg, K., Hagen, A., & Omholt, S. W. (2004). Altered physiology in worker honey bees (Hymenoptera: Apidae) infested with the mite Varroa destructor (Acari: Varroidae): a factor in colony loss during overwintering?. *Journal of economic entomology*, *97*(3), 741-747.

Anderson, D. L., & Trueman, J. W. H. (2000). Varroa jacobsoni (Acari: Varroidae) is more than one species. *Experimental & applied acarology*, *24*, 165-189.

Bakandritsons, N., & Zabunis, A. (1985). The tobacco leaves effectiveness in the control of varroatosis of honeybees. proc. XXX. Int. Apic. Cong. Nagoya, Japan.

Boecking, O., & Spivak, M. (1999). Behavioral defenses of honey bees against Varroa jacobsoni Oud. Apidologie, 30(2-3), 141-158.

Bogdanov, S., Ruoff, K., & Oddo, L. P. (2004). Physico-chemical methods for the characterisation of unifloral honeys: a review. *Apidologie*, *35*(Suppl. 1), S4-S17.

Cakmak, I., Aydin, L., & Wells, H. (2006). Walnut leaf smoke versus mint leaves in conjunction with pollen traps for control of Varroa destructor.

Çetin, M. (2010). *Bal arısı (Apis mellifera L.,) kolonilerinde varroa destructorun kontrolünde bitkisel, kimyasal ve biyoteknik uygulama yöntemlerinin karşılaştırılması* (Master's thesis, Fen Bilimleri Enstitüsü).

Damiani, N., Gende, L. B., Bailac, P., Marcangeli, J. A., & Eguaras, M. J. (2009). Acaricidal and insecticidal activity of essential oils on Varroa destructor (Acari: Varroidae) and Apis mellifera (Hymenoptera: Apidae). *Parasitology research*, *106*, 145-152.

Damiani, N., Gende, L. B., Maggi, M. D., Palacios, S., Marcangeli, J. A., & Eguaras, M. J. (2011). Repellent and acaricidal effects of botanical extracts on Varroa destructor. *Parasitology research*, *108*, 79-86.

Danka, R. G., Harris, J. W., & Villa, J. D. (2011). Expression of Varroa sensitive hygiene (VSH) in commercial VSH honey bees (Hymenoptera: Apidae). *Journal of economic entomology*, *104*(3), 745-749.

de Miranda, J. R., Cordoni, G., & Budge, G. (2010). The acute bee paralysis virus–Kashmir bee virus–Israeli acute paralysis virus complex. *Journal of invertebrate pathology*, *103*, S30-S47.

Delaplane, K. S. (1992). Survey of miticide use in Georgia honey bee hives. American Bee Journal, 132(3), 185-187.

Devi, S., Devi, M., & Barwar, C. (2019). Different methods for the management of varroa mite (Varroa destructor) in honey bee colony. *J. Entomol. Zool. Stud*, *7*, 178-182.

Drescher, N., Klein, A. M., Neumann, P., Yañez, O., & Leonhardt, S. D. (2017). Inside honeybee hives: Impact of natural propolis on the ectoparasitic mite Varroa destructor and viruses. *Insects*, *8*(1), 15.

Ellis, J. D., & Hayes, G. W. (2009). Integrated Pest Management (IPM) in beekeeping: Principles and practices. *American Bee Journal, 149*(4), 333-338.

Erban, T., Harant, K., Hubalek, M., Vitamvas, P., Kamler, M., Poltronieri, P., ... & Titera, D. (2015). In-depth proteomic analysis of Varroa destructor: Detection of DWV-complex, ABPV, VdMLV and honeybee proteins in the mite. *Scientific Reports*, *5*(1), 13907.

Garbian, Y., Maori, E., Kalev, H., Shafir, S., & Sela, I. (2012). Bidirectional transfer of RNAi between honey bee and Varroa destructor: Varroa gene silencing reduces Varroa population. *PLoS pathogens*, *8*(12), e1003035.

García-Fernández, P., Santiago-Álvarez, C., & Quesada-Moraga, E. (2008). Pathogenicity and thermal biology of mitosporic fungi as potential microbial control agents of Varroa destructor (Acari: Mesostigmata), an ectoparasitic mite of honey bee, Apis mellifera (Hymenoptera: Apidae). *Apidologie*, *39*(6), 662-673.

Gregorc, A., & Planinc, I. (2002). The control of Varroa destructor using oxalic acid. *The Veterinary Journal*, *163*(3), 306-310.

Haber, A. I., Steinhauer, N. A., & vanEngelsdorp, D. (2019). Use of chemical and nonchemical methods for the control of Varroa destructor (Acari: Varroidae) and associated winter colony losses in US beekeeping operations. *Journal of Economic Entomology*, *112*(4), 1509-1525.

Imdorf, A., Bogdanov, S., Ochoa, R. I., & Calderone, N. W. (1999). Use of essential oils for the control of Varroa jacobsoni Oud. in honey bee colonies. *Apidologie*, *30*(2-3), 209-228.

Imdorf, A., Charriere, J. D., Maqueln, C., Kilchenmann, V., & Bachofen, B. (1996). Alternative varroa control. *American Bee Journal*, *136*(3), 189-194.

Islam N, Amjad M, Haq E, Stephen E, Naz F. (2016). Management of Varroa destructor by essential oils and formic acid in Apis Mellifera L inn. Colonies. *J. Entomol Zool. Stud.,* 4(6): 97–104.

Jack, C. J., & Ellis, J. D. (2021). Integrated pest management control of Varroa destructor (Acari: Varroidae), the most damaging pest of (Apis mellifera L.(Hymenoptera: Apidae)) colonies. *Journal of Insect Science*, *21*(5), 6.

Karapınar, Z., Oğuz, B., Dinçer, E., & Öztürk, C. (2018). Phylogenetic analysis of black queen cell virus and deformed wing virus in honeybee colonies infected by mites in Van, Eastern Turkey.

Muz, M. N., Aslan, S., & Girişgin, A. O. (2014). Balarılarında varroa destructor enfestasyonuna karşı pudra şekeri etkinliğinin araştırılması. *Uludağ Üniversitesi Veteriner Fakültesi Dergisi*, *33*(1-2), 21-26.

Posada-Florez, F., Ryabov, E. V., Heerman, M. C., Chen, Y., Evans, J. D., Sonenshine, D. E., & Cook, S. C. (2020). Varroa destructor mites vector and transmit pathogenic honey bee viruses acquired from an artificial diet. *PLoS one*, *15*(11), e0242688.

Qayyoum, M. A., Khan, B. S., & Bashir, M. H. (2013). Efficacy of plant extracts against honey bee mite, Varroa destructor (Acari: Varroidae).

Refaei, G. S. (2011). Evaluation of some natural substances against Varroa destructor infesting honeybee, Apis mellifera in Egypt. *Egyptian Journal of Agricultural Research*, *89*(1), 169-175.

Rosenkranz, P., Aumeier, P., & Ziegelmann, B. (2010). Biology and control of Varroa destructor. *Journal of invertebrate pathology*, *103*, S96-S119.

Rucker, R. R., Thurman, W. N., & Burgett, M. (2012). Honey bee pollination markets and the internalization of reciprocal benefits. *American Journal of Agricultural Economics*, *94*(4), 956-977.

Sabahi, Q., Morfin, N., Nehzati-Paghaleh, G., & Guzman-Novoa, E. (2020). Detection and replication of deformed wing virus and black queen cell virus in parasitic mites, Varroa destructor, from Iranian honey bee (Apis mellifera) colonies. *Journal of Apicultural Research*, *59*(2), 211-217.

Sammataro, D., Gerson, U., & Needham, G. (2000). Parasitic mites of honey bees: life history, implications, and impact. *Annual review of entomology*, *45*(1), 519-548.

Satta, A., Floris, I., Eguaras, M., Cabras, P., Garau, V. L., & Melis, M. (2005). Formic acid-based treatments for control of Varroa destructor in a Mediterranean area. *Journal of economic entomology*, *98*(2), 267-273.

Shaarawi, M. O. A. (1995, August). Evaluation of Several Natural Materials as Control Agents against Varroa jacobsoni Oud. In *Infesting Honeybee Colonies. The XXXIVth International Apicultural Congress. Lausanne, SWİTZERLAND* (pp. 15-19).

Shen, M., Yang, X., Cox-Foster, D., & Cui, L. (2005). The role of varroa mites in infections of Kashmir bee virus (KBV) and deformed wing virus (DWV) in honey bees. *Virology*, *342*(1), 141-149.

Sofou, K., Isaakidis, D., Spyros, A., Büttner, A., Giannis, A., & Katerinopoulos, H. E. (2017). Use of costic acid, a natural extract from Dittrichia viscosa, for the control of Varroa destructor, a parasite of the European honey bee. *Beilstein journal of organic chemistry*, *13*(1), 952-959.

Stanimirović, Z., Glavinić, U., Lakić, N., Radović, D., Ristanić, M., Tarić, E., & Stevanović, J. (2017). Efficacy of plant-derived formulation "Argus Ras" in Varroa destructor control. *Acta Veterinaria*, *67*(2), 191-200.

Tsegaye, A., Desale, E., Tsegaye, A., Lemma, M., Grmay, A., Bihonegn, A., & Ibrahim, Y. (2024). Evaluation of the Efficiency of Different Biotechnical Techniques for the Control of Varroa Mite in Eastern Amhara. *Frontiers*, *10*(3), 61-65.

Turhan, M. (2024). Use Of Essentıal Oils Of Plants In Control Of Varroa. *Diagnosis And Treatment Methods Of Bee Dıseases*, 13-23.

Vilarem, C., Piou, V., Vogelweith, F., & Vétillard, A. (2021). Varroa destructor from the laboratory to the field: Control, biocontrol and ipm perspectives—A review. *Insects*, *12*(9), 800.

Wehling, M., Ohe, W., & Ohe, K. (2003). Natural content of formic and oxalic acids in honeys. Apiacta, 38,