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REVIEW

The use of humic acids in the fight against *Varroa destructor* (Mesostigmata: Varroidae)

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ABSTRACT: Humic acids, which are known for their use in agricultural areas and are very popular in this field, have the potential to be used for all living things. These acids are yellow to black in color and are a component of the humic substances found in the humus of the soil. They are fully decomposed remains of organic life and natural matters obtained as a result of the microbial degradation of plants. Humic acid refers to a complex mixture of many different organic acids soluble in alkaline solutions. These acids, we encounter in a different area every day, are important in the beekeeping sector, as well. Even though Türkiye has met all the requirements of the beekeeping sector in terms of both climate and wealth of flora, it is known that honeybees' health and quality and production of honey have fallen below the targeted levels. The major factor behind the low level of production and failing to keep bee colonies' health is that beekeepers insist on sticking to conventional methods. The nutrition and health of individuals in bee colonies directly affect the quality and amount of honey they make. For this reason, humic acids can be regarded as an alternative product in order to maintain their nutrition and health. In this review, the causes of *Varroa destructor* infestations, the applied control methods and the applicability of humic acids were examined.

Keywords: Humic acid, honeybee health, *Apis mellifera* L., bee health, bee paralysis virus, *Varroa destructor*.
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INTRODUCTION

Humic acids are natural and processable structures that form as a result of the decay of plants. They are yellow to black in colors, are hydrophilic and completely natural organic structures having a high molecular weight (Islam et al., 2005). They are biomolecules that are a complex mixture of many different organic acids (Sutton and Sposito, 2005) and have therapeutic properties owing to different functional groups (such as polyphenols, polycarboxylic acids and quinones) in their structure.

Humic acids, one of the important components of the soil, have the potential to be used in both human beings and animals, as they are reliable substances. They do not cause any harm like mutagens, do not leave remains in the body and feed of animals, and are also used to increase productivity in both poultry and cattle. As a result of changes in the metabolism of some nutrients such as salts of humic acids (humates) and carbohydrates, they increase cell membrane permeability and increase the absorption of nutrients (De Melo et al., 2016). Soluble sodium humates have been reported to be generally used in animal production as they increase the use of animal feed and stabilize the intestinal flora (Tunç et al., 2020). When the natural structure of humic acids is examined, it is known that they increase the resistance of animals against diseases and under stress conditions. Although it is used as feed additive of natural origin for these reasons, its use in beekeeping is quite limited. In addition, there are numerous studies on humic acids in the literature; however, there is a limited number of studies on beekeeping and the diseases of honeybees, and beekeepers do not know a lot about these acids. The studies have demonstrated that humic acids, which have attracted attention with their use for animal health and nutrition as well as in agricultural lands, have a wide area of influence. They positively affect animal health in ovine and bovine, boost meat and milk yield, and contribute to egg production in poultry.

When the natural structure of humic acids is examined, it is known that they increase the resistance of animals against diseases and under stress conditions. Although it is used as feed additive of natural origin for these reasons, its use in beekeeping is quite limited. In addition, there are numerous studies on humic acids in the literature; however, there is a limited number of studies on beekeeping and diseases of honey bees, and beekeepers do not know a lot about these acids. The studies have demonstrated that humic acids, which have attracted attention with their use for animal health and nutrition as well as in agricultural lands, have a wide area of influence. They positively affects animal health in ovine and bovine, boost meat and milk yield, and contribute to egg production in poultry. A study on chickens reported that humic acid had positive effects on their immune system (Sanmiguel and Rondón, 2016). These acids act as a shield in almost every area they are used, owing to their antiviral, antimicrobial, antioxidant, antibacterial, and antitumor properties (Sydow, 1986; Cronje et al., 1991; Riede et al., 1993; Kodama, 2007; Avvakumova et al., 2011; VanRensburg, 2015; Tunç and Yörük, 2017). They have the potential to be used in every field due to their ease of use and application, the continuity of their effect, the lack of any side effects and presence of their forms that can be used for all living things. These broad-spectrum properties reveal that humic acids can be utilized as drugs in medicine.

Beekeeping is an activity carried out with the aim of maximizing and managing adult bee populations during periods of increased nectar flow of honeybees (*Apis mellifera* L.) in order to produce honey and other honey products and to make use of these products for both economic and nutritional purposes (Sıralı and Doğaroğlu, 2005).

Türkiye is eligible for many sectors with its suitable climatic conditions, topographic structure and rich flora. One of these sectors is beekeeping. It has been reported that Türkiye ranks second in the world with approximately 8.5 million bees (TÜİK, 2021), and take place on the top in terms of hosting 22% of honeybee subspecies (Arslan and Cengiz, 2020). The total number of colonies, honey production and yield per colony have been increasing continuously since 1961 throughout the world. According to the 2021 agricultural statistics of the Food and Agriculture Organization of the United Nations, beekeepers obtain 96 thousand tons of honey from approximately 8.7 million beehives in Türkiye; however, the honey yield per beehive is still about 11 kg (Anonymous, 2022). Türkiye produces and trades honey alongside apicultural products such as royal jelly, pollen, propolis, wax, apilarnil, and queen bee (Sunay, 2006). Despite it seems good that Türkiye is a country rich in terms of the presence of bees and bee species, there are also weaknesses in terms of production, exportation, and bee health. Low honey production per colony below desired levels has been affecting Türkiye beekeepers economically despite Türkiye's bee colonies being genetically diverse. The most important factors affecting productivity include species selection, climate, vegetation, care, nutrition and maintenance of bee health. On the other hand, the primary factors restricting production and reducing yield are the nutrition and health of honeybees besides knowing the colony, detecting diseases and pests of honey bees and making an effective control in such cases.

It is a well-known fact that beekeepers, who have difficulties in maintaining the health and sustainability of bee colonies, do not know exactly the methods of combating the diseases and cannot take the necessary intervention timely. In addition, thinking that everyone can earn revenue through beekeeping, having insufficient knowledge and education, lack of organization among beekeepers, lack of information sharing between farmers and beekeepers, use of water interacted with pesticides, application of pesticides during the daytime and inadequate bee breeding are other beekeeping problems (Soysal and Gürcan, 2005).

Although these problems show their effects very quickly, high losses in the colonies in recent years have led beekeepers to seek new ways and investigate the causes of these losses. One of the issues that beekeepers suffer from is the existence of an external parasite, *Varroa destructor*, which has been affecting the whole world for many years (Anonymous, 2021). Despite numerous studies on this parasite, no clear results have been reached in terms of its control and complete elimination (Le Conte et al., 2010; Akyol and Yeninar, 2011). Even though many other bee diseases are struggling, international studies on colony losses have shown that *V. destructor* parasite has an important share in these losses (Giray et al., 2010).

Many methods have been investigated and different methods have been applied to fight against *V. destructor*, a dangerous parasite that lives by sucking the blood of honeybees in all their life stages, including larvae, pupae and adults. Fighting against *V. destructor* is based on chemical, mechanical, genetic and biological methods (Carreck, 2011). The intensive use of chemicals in the struggle against *V. destructor* has adversely affected bee and human health so far. Difficulties experienced in practice are among the other factors affecting beekeepers. According to researches, *V. destructor* has developed resistance to some chemicals and it reduces the effectiveness of the drugs used over time (Pettis, 2004; Yücel, 2005).

Drugs used for *Varroa destructor*, fighting methods and humic acids

Chemical drugs containing the active ingredients Fluvalinate, Flumethrin, Amitraz and Coumaphos are widely used in the fight against *V. destructor* in the world. (Eguaras et al., 2003). However, recent reports have demonstrated that the parasite has gained resistance to these chemicals, leaves residues in honey and beeswax, and is not effective in capped brood cells (Spreafico et al., 2001). These drugs should be applied in the early spring period when there are no or less capped brood cells in the hive, or in the late autumn period after the honey harvest so that they are effective. Successfully fighting against this parasite requires the right drug at the right time and the right dose. Organic acids and essential oils such as thymol have been used as alternatives because different drugs used both threaten human health by leaving residue in honey and develop resistance to these drugs (Kumova, 2001; Akyol and Özkök, 2005).

Koeniger and Fuchs (1988) reported that an efficiency of 95.6% is obtained when Fluvalinate is used during the brood period in honeybee colonies for the control of *V. destructor*. Kaftanoğlu et al. (1995) determined that the activity level of chemicals such as Amitraz, Perizin® formic acid, fluvalinate, Apistan®, and Vamitrat® on *V. destructor*, were 96.0%, 93.1%, 92.8%, 87.3%, 73.3%, and 70.8%, respectively. The number of dead bees in these groups was 14.9, 19.5, 23.2, 30.4, 44.2 and 98.3 units/colony, respectively. In the study by Kumova (2001), it was reported that the effect of Fluvalinate, Amitraz and Coumaphos was 97.3%, 91.1% and 83.4%, respectively. In the study by Portakal and Yarsan (2010), it was determined that Flumethrin and Coumaphos were effective at the rates of 87.7% and 72.7%. As a result, it was reported that the applications made in the larval-free stage were more successful than the larval stage and Flumethrin was more effective than Coumaphos. Similar results have been obtained so far when the mentioned active ingredients are used in the fight against *V. destructor*.

In a study investigating the effects of different insecticides and acaricides on *V. destructor* and honeybees, it was found that their treatment was effective in autumn at 15-

75% and in spring at 68-75% (Kumova, 1987). Although acaricides are preferred by beekeepers due to their low cost and ease of use, they cause the death of bees. Numerous countries have posed bans on some acaricides that leave residues in honey and other apicultural products (Johnson et al., 2009).

Organic acids and essential oils such as thymol have been used as alternatives because different drugs used both threaten human health by leaving residue in honey and develop resistance to these drugs (Kumova, 2001; Akyol ve Özkök, 2005). Numerous countries prefer organic acids such as oxalic acid and lactic acid day by day in terms of their effectiveness against *V. destructor*, easy to apply and low cost (Mutinelli et al., 1997).

In a study investigating the effects of oxalic, formic and lactic acids on control and colony growth of *V. destructor* under known standard conditions (early spring and late autumn) in colonies, Yücel (2005) determined the effectiveness of oxalic acid against *V. destructor* as 94.04% in spring. This value was higher than formic acid and lactic acid. Also formic acid was lower than oxalic acid and lactic acid in the development of the brood population in autumn.

Akyol and Yeninar (2009) determined an efficiency level of 93.4% in the autumn treatment of oxalic acid among honeybee (*A. mellifera* L.) colonies with a varroa infestation level of around 25%. In addition, there was no queen loss, brood and adult bee death in the colony during the treatment. Cengiz (2012) investigated the effects of oxalic acid, thymol and lactic acid on colony growth and fighting against *V. destructor* in Erzurum region. At the end of the treatment, the efficacies of oxalic acid, thymol and lactic acid groups against *V. destructor* were 84.90±5.60, 90.10±3.03, and 79.50±3.78%, respectively. When they applied oxalic acid to the *V. destructor* population in the early spring (March), summer (July) and late autumn (October) periods, Akyol and Ünalan (2017), reported the average efficiencies as 80.22%, 69.72% and 84.61%, respectively. According to these results, it was determined that oxalic acid application in late autumn and early spring was approximately 21% and 15% more effective than in summer, respectively.

Upon the literature research, it has been seen that drug residues are another factor that affects food safety and threatens human health, as well as not producing an effective solution against *V. destructor*. These residues are also a major market problem. On the other hand, importance is placed on the establishment of bee lines resistant to bee diseases and the implementation of natural applications in a way that does not disturb the structure of honey in American and European countries (Akyol and Özkök, 2005). However, the fact that these applications are difficult to implement in every country makes the struggle difficult again. The existence of important resources obtained from domestic and national raw materials in Türkiye should not be ignored. One of these resources is humic acids, which find many areas of application owing to their broad-spectrum properties. In addition, successful results obtained in cattle and poultry have led to the idea that humic acids would play an important role in bee health. In their study investigating the effects of humic acids on bees, Tunç et al., (2020) reported that honey yield per colony increased significantly with 10 cc sodium humate applied in syrup, the colony strengthened and brood production increased with the treatment in early spring. The commercial product containing Olvit brand humic acid, which was used as a feed additive before, was applied based on voluntariness against *V. destructor* in 70 colonies. The information we received from beekeepers who applied humic acid in their hives during field research, revealed that the product had a positive effect on the health of bees. We obtained the following results from beekeepers who have faced many problems in their hives. Humic acids completely eliminate Nosema, which is a digestive disorder, and *V. destructor* infestation, as they increase the physiological activity in the stomach and intestine of bees. Due to their antiviral effect, they are effective against viruses, they prevent the chalkbrood disease caused by turning color of the dead larvae into white and calcifying them. In addition, other effects of these acids are that they provide a significant growth in the height of the bees and prevent foulbrood by providing advanced brood abortion. It is thought that humic acids shall be an important source that both protects the bees from many diseases and enhances the quality of honey by strengthening their immune system as in other living things. They prevent nutrition-related deaths by providing an effective micronutrient transfer, remove toxic substances that may occur in the hive or come from outside, and also destroy all pesticides that pass from plants to bees in areas where chemical fertilization and pesticides are used intensively (Anonymous, 2020).

Measures to be taken in fight against *Varroa destructor*

Although many drugs and chemicals are used in the fight against *V. destructor*, beekeeping techniques should be reviewed and developed in order to benefit from beekeeping economically and to become professional in this field. In the breeding seasons when number of varroa increases, the control of the hives should be done at regular intervals and consciously. Hives that have lost their queen bees for unknown reasons, weakened in strength, have a decreased population and are highly contaminated with mites should be destroyed without delay as they constitute a source for the spread of the pest to the environment. Adult field bees leave their hives in the highly infested colony (Tutkun and Boşgelmez, 2003). Beekeepers should avoid using old honeycombs that may carry eggs of varroa or other parasites into the hives, introducing brood combs and young worker bees to the colonies, and uniting weak colonies. In order to prevent the transfer of mites to other apiaries through swarms escaping from the hive, apiaries should be visited frequently and swarm prevention methods should be applied in a timely manner by making divisions in the colonies that are understood to swarm (Uygur and Girişgin, 2008; Anonymous, 2010; Uzundumlu et al., 2011).

Beekeepers who believed that antibiotics and chemicals used in the fight against *V. destructor* would be beneficial for their colonies suffered losses. Unnecessary drug use,

administering drugs based on what they hear from other people and lack of information have weakened beekeepers economically every year.

The integrated control method requires the use of control methods before it reaches the level where *V. destructor* can feel its effect. A program that can be defined as an ideal integrated control method in the fight against *V. destructor* has not been found, yet. Infestation level of varroa varies from region to region, and it is reported that it should be checked more frequently than other periods due to reasons such as different applications of breeders, climatic conditions and high population (Anonymous 2001; Kumova, 2001).

Today, many countries that are successful in beekeeping look for ways to get rid of *V. destructor* without giving chemicals to the colonies and carry out highly effective studies. While synthetic substances fight against *V. destructor* parasites, they cause intense bee deaths and lower the economic value of honey by leaving residues in honey and beeswax. However, until now, a more accessible, low-cost, and more effective control technique that neutralizes *V. destructor*, other than chemicals, has not been found, yet. In beekeeping, many countries have started to use biotechnical methods, various organic acid applications, the use of essential oils of aromatic plants, and control methods that require the use of chemicals in an integrated control system, thus resulting in positive results (Kumova, 2001; Akyol and Özkök, 2005). In beekeeping, many countries have started to use biotechnical methods, various organic acid applications, the use of essential oils of aromatic plants, and control methods that require the use of chemicals in an integrated control system, thus resulting in positive results. However, organic acids and essential oils used in the fight against *V. destructor* and obtained naturally are high cost; therefore, synthetic ones are preferred. Therefore, it would be more accurate to consider them as chemical drugs.

The fight against *V. destructor* is carried out in the early spring and late autumn, and the treatments in autumn are very important. Because the winter comes after the autumn struggle, the bees form winter clusters and it is difficult to intervene in the colony in this season, it will be difficult to compensate for the mistakes and deficiencies in this control. Since one of the important factors affecting the control is nutrition, it is considered to be the main cause of late winter deaths. When honeybees cannot get the necessary nutrients, the protein concentration in the body and the formation of immune response are adversely affected. It is thought that this situation causes stress within the colony and thus leads to colony losses (Degrandi-Hoffman et al., 2010). Since humic acids are substances that increase nutrient utilization, they are thought to have the potential to prevent nutrition-related deaths (Anonymous, 2020). The ambition to earn money causes the honey bees to die of hunger when enough honey and pollen are not left in the hives during the winter months. A large number of colonies were used in hygienic test applications made by selecting colonies resistant to *V. destructor*, but positive results could not be obtained. It seems to be an easy solution due to the simple applicability of hygienic tests. However, although all capped brood cells of some colonies were completely cleared within 24 hours, it was reported that these colonies died of *V. destructor* (Çakmak, 2010).

The past and future of the fight against *Varroa destructor*

Fighting against *V. destructor* is of vital importance for the beekeeping industry since it poses economic damages to colonies and beekeepers (Kumova, 2001). Hence, beekeepers must observe their hives and bees very well and have sufficient knowledge and qualification to detect diseases that may develop in the hives. Benefiting from beekeeping economically is possible by providing appropriate care and feeding conditions and keeping bee health at the highest level in an environment where the bee species can adapt. Therefore, it is essential to regularly fight against *V. destructor* (Aydın, 2001; Kuvancı et al., 2017). One of the issues we have mastered on during the pandemic has been online education. Beekeepers should be encouraged to participate in online or face-to-face trainings, and common platforms and media where they can ask questions should be established.

Many methods have been developed to fight against *V. destructor*, but physical control works have not gained practicality and applicability since optimum conditions cannot be provided (Anonymous, 2010).

It has been concluded that a visible success has not been achieved in the control works made with biological methods, these methods alone have fallen short, these methods have not yielded accurate results in highly infested colonies, and different applications should be evaluated and performed together. Studies conducted in the last 30 years have emphasized that biological methods alone are insufficient (Marletto et al., 1991; Wilkinson and Smith, 2001).

Chemical control is the most commonly used method in the fight against *V. destructor*. However, chemical products used in Türkiye and around the world, which negatively affect bee and human health, and leave residues in honey and beeswax, are among the main problems of beekeeping. It is necessary to be very careful in the use of chemicals that cause the parasite to gain immunity (Akyol and Özkök, 2005). The use of natural compounds that have a high effect against mites and do not adversely affect human and bee health should be encouraged by limiting the use of chemical products.

Until today, chemicals have been used excessively in the control of *V. destructor* and the targeted success for mite control has been achieved in applications. However, due to the differences in the reproductive biology of honeybees and *V. destructor*, the use of chemicals could not completely remove the parasite, and has kept it below the economic damage threshold that the mites can cause by using them for a long time (Akyol and Özkök, 2005).

The properties of the chemicals to be used in the control of *V. destructor*, the way of using them, the dose amount and the potency are important. Overdose, bad timing and use of chemicals bring along many undesirable side ef-

fects. The most important side effect is the emergence of drug-resistant populations among mites. The mites that gain this feature survive in the colony after spraying despite the chemical substances (Kumova, 2001; Mitchell et al., 2017; Rinkevich et al., 2017).

The presence of capped pupa cells in the hive is important for the effectiveness of chemicals. Drugs used against *V. destructor* should not adversely affect queen bees and other colony individuals. The drug application should be repeated several times depending on the characteristics of the chemicals, their effect on honeybees and the level of infestation in the colony. While the effectiveness of many chemicals used today varies between 70-95%, it has been observed that it reduces the number of parasites instead of completely eliminating the mites from the colony. If the density of mites in the hive can be reduced below 1% with cultural measures and an effective control, the physiological activities of colony individuals can continue for a long time without interruption (Tutkun and Boşgelmez, 2003).

Another point to be considered in chemical control is the implementation of treatments that will not harm human health as well as bee and colony health. Medicines containing Perizin and Fluvalinate with the active ingredient Coumaphos are quite harmful for human health. It has been observed that drugs containing Coumaphos are not effective against mites in capped brood cells (Spreafico et al., 2001).

V. destructor completes its development period on bee larvae and pupae in capped cells and drugs are ineffective against mites during this period (Rosenkranz et al., 2010). Today, except for systemic drugs that affect the metabolic systems of *V. destructor*, none of the systemic drugs and those showing action by touch and contact has the capability to kill the mites in capped brood cells during their developmental period. This makes the fight against mites very difficult. The chemicals used in the control of *V. destructor* are given on adult bees by dropping, spraying, smoking, and food of bees in stripe form (Gregorc and Planinc, 2004).

Honeybees serve all humanity with the products they produce. These products contribute to food, health, ecological balance, biodiversity, and agricultural production. Bee diseases and pests should be minimized and the extinction of colonies should be prevented so that this continuity is ensured. Considering the techniques applied in the colonies and the beekeeping sector, the yield decreases in colonies with poor quality queen bees (Anderson and Trueman, 2000; Aydın, 2001; Kuvancı et al., 2017).

The studies have proven that *V. destructor* has a significant effect on winter losses in colonies. The precautions to maintain health of colonies and ensure their survival during the year include having strong colonies for the winter, well colony nutrition, and separation of weak colonies. Beekeepers should have young and productive queens. However, they should take this precaution for in colonies that have to survive in modern beehives based on their education and knowledge. Therefore, they should have a high level of knowledge about nutritional physiology of colonies. It is necessary to feed the colonies at certain periods in order to ensure that they develop at a level suitable for that period and start the intense nectar flow with a strong population. The supplementary nutrients given to the colonies and various substances mixed into the syrup increase (Kuvancı et al., 2017). The supplementary nutrients given to the colonies and various substances mixed into the syrup increase the colony population as well as production of honey and beeswax (Kumova, 2000). Better productivity should be targeted by making use of the colonies for a longer period of time. It is essential to have colonies resistant to mites, select them from different regions and rear queen bees from these colonies in order to minimize colony losses.

When considering all bee diseases in general, beekeepers should know the content of the licensed products to be used in the control. Control should be done outside the nectar period and in sick colonies. Beekeeping should be done not with conventional methods but with technological methods, and the honeycombs in the colonies must be replaced with new ones during the control.

If chemical control continues and natural control methods are not developed, bee and human health will continue to be under threat. (Milani, 1999; Kumova, 2001).

Today, there are approximately 8.5 million bee colonies in Türkiye (TÜİK, 2021). It costs one dollar to spray each beehive once a year. The total cost of drugs used in the fight against *V. destructor* is around 15-25 million dollars (Turhan and Şengül, 2020). When the honey and colony losses in the colonies infested by *V. destructor* are added to all these economic losses, the damage rate increases exponentially, and so many beekeepers give up on their job over time. The chemicals used in the fight are both expensive and often cause serious damage to bee colonies. In order to solve all these problems optimally, it is necessary to find the best control methods that are low in cost, have a high effect, do not leave any residue on honey and beeswax, and do not have an adverse effect the honey production of bee colonies and the development of the population, but only affect *V. destructor*.

Making a one-way fight against these mites using only chemicals and expecting a definite result from this treatment will mislead the beekeepers resulting in material and moral losses (Kumova 2001; Akyol and Korkmaz 2006; Kuvancı et al., 2013).

In their study, Cengiz et al., (2010), reported that various methods are used to fight against these mites around the world and chemical control is the most common. They reported that organic acids are one of the most effective and residue-free methods because chemical control threatens bee and human health. However, organic acids often irritate the skin, causing allergic reactions and skin inflammation in human beings and making it difficult for beekeepers during their treatment. In addition, people can feel taste of lactic acid, which is one of the organic acids and found in the structure of honey, while consum-

ing honey when used for the control of *V. destructor* (Anonymous, 2001).

In the fight against bee diseases, nearly 150 drugs obtained from fumigants, acaricides, insecticides and vegetable oils were used, but the fight against mites could not be completed (Cobey and Lawrence, 1988). The control works against *V. destructor* should be rotated every year and it should not be thought that the method applied for one year would also be effective in other years. Colonies should be constantly followed in order to determine the level of mite infestation in the colonies and which control method will be used in which period (Kumova, 2001; Akyol and Özkök, 2005).

Attention should also be paid to the selection of drugs used in the fight against *V. destructor*. While the selected drug needs to kill the mites, it should not leave any residue on the honeycomb and should not harm human health. For these reasons, mites control can be done with organic acids such as oxalic acid, lactic acid, and formic acid and natural mixtures consisting of essential oils such as thymol in order to find an alternative when excessive residues are encountered on the honeycomb from time to time in the control with synthetic chemicals and the mites become resistant to these drugs. Bee mortality rates vary according to seasonal periods. Although bee losses are almost negligible in the summer months, the bee deaths have been observed mostly at the end of winter, especially since 2006. If colony mortality occurs during the winter months, it may take a long time until the beekeeper realizes it, and clues for the cause of bee deaths often disappear (VanEngelsdorp and Meixner, 2010). After the honey harvest, the long pre-foraging period and inadequate and untimely nutrition lead to starvation, which is one of the most common causes of deaths at the end of winter. However, these deaths are common in colony management and it is beekeepers' responsibility to prevent this (VanEngelsdorp et al., 2010).

It is an important fact that *V. destructor* not only negatively affects honey production, but also reduces the production potential of all apicultural products of economic importance. Honeybees also contribute significantly to pollination of plants but the damage done by the mites on the bees causes a decrease in both their pollination efficiency and the yield of the plants (Goodwin and VanEaton, 2001; Akyol and Korkmaz, 2005). Honeybees characteristically collect pollen from many different plant species, providing a different diet and balance for their bodies. Honeybee colonies, which are used for pollination in agricultural lands today, are faced with a diet with less diverse pollen content due to the cultivation of a single type of plant (Monoculture) in these lands, and this diet does not meet all the nutritional needs of honeybees. In general, diets containing one type of pollen are considered insufficient compared to mixed diets. If honeybees feed with a single type of pollen that lacks an essential nutrient, they will not be able to make up for the missing substance by consuming this poor quality pollen more. Therefore, it is thought that this nutritional stress may cause high colony mortality. In addition, a mixed diet increases some immune system properties by making the honeybee body more resistant to external factors (Alaux et al., 2010).

In the fight against *V. destructor*, it is suggested to obtain sufficient information about the effects, uses, and application forms of drugs and organic acids, not to ignore that the drugs will interact with each other and will be one of the main causes of bee deaths, and to prohibit the use of drugs that increase toxicity. It is also suggested to limit the use of pesticides and synthetic fertilizers in gardens and agricultural lands and for especially migratory beekeepers to carry out beekeeping activities in areas close to the soil where humic acids are used as fertilizer. Therefore, beekeeper-farmer cooperation is also important.

Considering the position of technology and the world, as in all bee diseases, the control that leaves no residue in *V. destructor* and does not require the use of chemical drugs is at the forefront. Despite all the methods used in the control, it has been observed that there is no effective and practical method without the use of chemicals. Again, testing the efficiency levels of the chemicals used and biological control methods are difficult and costly, even if many different treatments are made (Wilkinson and Smith, 2002). Colonies develop resistance to drugs such as Bromopropylate, Fluvalinate, Amitraz, Flumethrin and Coumaphos, which are the most commonly used and leave residues in the control of *V. destructor*, making it difficult to fight against mites. Another issue to consider is that it causes significant losses in the colonies (Milani, 1999; Elzen et al., 2000; Spreafico et al., 2001; Girişgin and Aydın, 2010). All applications made in the colonies should be evaluated comprehensively. The use of organic acids is difficult and requires attention due to their effects on human health. Essential oils are regarded as a stressor because of their distinctive heavy odors. This can sometimes cause colony losses. There are organic acids in the structure of honey and other nutrients and there is no residue problem. However, resistance of *V. destructor* to these drugs has not been reported to date. In addition, when organic acids are used excessively, they change the taste of honey and cause financial losses by causing a marketing problem.

The effects of antibiotics are also one of the issues that should not be forgotten. Although it is prohibited, the use of antibiotics in the control creates a residue problem and weakens the immune system of bees, causing pathogenic bacteria to gain resistance and destroy their microflora (Bogdanov, 2006; Borum, 2015). *V. destructor* is the archenemy of beekeepers and honeybees. Although beekeepers think that the drugs they use in the fight against mites, which are difficult to control, are effective, their losses are increasing every year (Çakmak, 2012). The recommended precautions to benefit from the colonies at the highest level, to increase honey yield, and to maintain the health of the colony are increasing the presence of bees, elevating the resistance of the damaged colonies, encouraging the queen to lay eggs, applying the drugs, to be used for the diseases in the colony, to bees, and increasing the growth rate of colonies (Oskay and Sönmez Oskay, 2017).

In colonies infested with *V. destructor*, it is necessary to create water resources for bees in front of the hive in the apiary and make some changes in their feeding habits (Tutkun and Boşgelmez, 2003). In addition, nutritious foods containing humic acid should be added to the water so that the bees can benefit from them. It is also important to use separate containers for feedings. As in all areas, attention should be paid to cleanliness in the colonies, especially after the honey harvest, honey residues in the combs should be cleaned.

DISCUSSION

Varroa destructor is a parasite that has a vital role in the spreading of various bacterial and fungal diseases as well as viral diseases to bees. Humic acids and nutritious feeds containing humic acid can be promising in preventing both *V. destructor* and other bee diseases.

It is thought that instead of different organic acids, chemical drugs and essential oils in every period, products containing humic acid, which has the effect of regulating the intestinal flora and has strong antiviral properties, will be sufficient and will not harm the colony and brood cells. While humic acids provide protection against diseases in bees, as in other living things, it is thought that they will contribute to honey production and growth of the colony and improve the behavior and yield characteristics of bees with different organic-based struggles applied. Instead of making different choices according to the conditions of the beekeeper, solving the problems of all beekeeping activities with a single product and perhaps without the need for inter-period transformation is important both in terms of cost and the maintenance of colony health. For this reason, humic acids can be converted and their use in other animals has the potential to be encouraged, as they are products with positive results.

Humic acid application of beekeepers who have lost hope in their colony and are about to give up beekeeping, completely eliminating nosema, chalkbrood, foulbrood and stonebrood diseases, especially *V. destructor*, gives great hope in terms of beekeeping. Humic acids and Olvit brand products are important because they will be studied and applied for the first time in Türkiye and in the world, they are not difficult to apply like other acids, they do not harm any living thing in nature, and most importantly, they are affordable, effective, local and national product. In addition, humic acids shed light on many scientists to conduct further studies on this subject. There is a need for more comprehensive studies on humic acid in Türkiye, especially for vector-borne viral, bacterial and fungal infections. Humic Acid Research Centers are recommended to be established due to the studies carried out to date and its known effects on all living things.

Authors' contributions

Raşit Fikret Yılmaz: Conceptualization, writing - original draft (lead), writing - review & editing (lead). **Mümin Dizman:** Writing - original draft (supporting), writing - review & editing (supporting).

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