Acaricidal Effect of Plant Extracts in *Dermanyssus gallinae*

Sahar Mustafa[1,*], Anas Sarwar Qureshi[2], Syed Khalil ud Din Shah[3], Farrah Deeba[1], Mudassar Nazar[4], Asif Ali Butt[5], Qari Muhammad Kaleem[6], Muhammad Ijaz Saleem[1], Atiq ur Rehman[3] and Tahir Sultan[1]

[1]Department of Clinical Medicine and Surgery, University of Agriculture, Faisalabad
[2]Department of Basic Bioscience, Ripah College of Veterinary Sciences, Ripah International University, Lahore, Pakistan
[3]Livestock & Dairy Development Department, Balochistan, Pakistan
[4]University of Agriculture, Faisalabad, Constituent College Burewala
[5]Ripah International University (Faisalabad Campus) Pakistan
[6]Centers of Excellence in Science and Applied Technology (CESAT)
*Corresponding author: saharmustafa30@gmail.com

Abstract

Dermanyssus gallinae (*D. gallinae*) is a hematophagous parasite, known as poultry red mites, and causes huge economic losses in poultry. It acts as a vector and reservoir of bacterial and viral pathogens, a few of which have zoonotic importance like avian influenza A virus, *S. enteritidis*, *Borrelia burgdorferi.* Different drugs such as Ivermectin, Organophosphorus, Phoxim, Spinosad, and Fluralaner have been used against *D. gallinae*. However, their efficacy has decreased due to the development of resistance. Therefore, attention has been diverted toward safe, eco-friendly, and effective alternatives. One of them is the use of plant extracts because of the presence of various active compounds. From these compounds, secondary metabolites (phenol, flavonoid, tannins) are most important because they give best and most effective acaricidal effects against *Dermanyssus gallinae*. These compounds give acaricidal effects by cuticle disruption, neurotoxicity, cell membrane damage, oxidative stress induction, and respiratory inhibition. This chapter discusses the acaricidal effect of different plant extracts and their mode of action against *D. gallinae*. Economic importance and zoonotic importance of *D. gallinae*. It will also describe the combined effect of different plant extracts and the limitations of these plants.

Keywords: Acaricidal plants, *D. gallinae*, Limitations, Secondary metabolites, Zoonotic importance

Cite this Article as: Mustafa S, Qureshi AS, Shah SKUD, Deeba F, Nazar M, Butt AA, Kaleem QM, Saleem MI, Rehman AU and Sultan T, 2025. Acaricidal effect of plant extracts in *Dermanyssus gallinae*. In: Khan A, Hussain R, Tahir S and Ghafoor N (eds), Medicinal Plants and Aromatics: A Holistic Health Perspective. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 23-29. https://doi.org/10.47278/book.HH/2025.203

A Publication of Unique Scientific Publishers	**Chapter No:** 25-004	**Received:** 05-Feb-2025 **Revised:** 06-March-2025 **Accepted:** 08-Apr-2025

Introduction

Dermanyssus gallinae, commonly known as poultry red mites, affect humans especially, poultry species, e.g., layers, ducks, pigeons, and canaries (Tabari et al., 2020; Omeragić et al., 2024). Annually, millions of Euro losses have been recorded because of blood-feeding habits in humans and poultry birds (Roy et al., 2021). These mites are small in size, hidden in crevices in poultry houses and chicken coops, during the daytime, and feed at night (Jian et al., 2022). These mites cause restlessness, skin irritation, head scratching, body shaking, reduced development, anemia, and changes in egg quality and productivity of poultry birds (Kilpinen et al., 2005; Pavličević et al., 2019; Sleeckx et al., 2019; Schreiter et al., 2022; Sárkány et al., 2025). Due to *D. gallinae,* EUR 130 million/y losses were recorded in the egg laying sector of the European Union because of high expenses on productivity and preventive measures (Sparagano, 2020). In severely contaminated areas of *D. gallinae*, poultry workers can be infected and show itching, dermatitis, rashes, papules, etc. on different body parts (Kavallari et al., 2018; Sioutas et al., 2021). It also serves as a vector and reservoir of many pathogens like, paramyxovirus, *E. coli, Salmonella gallinarum, Salmonella enteriditis*, *Erysipelothrix rhusiopathiae, Pasturella multocida*, *Avian influenza*, equine encephalomyelitis (Venezuelan, Eastern, and Western) virus (Mustafa & Alsayeqh, 2025). Therefore, there is a dire need for its control.

Different drugs like Ivermectin, Spinosad, Organophosphorus, Phoxim, and Fluralaner have been applied against *D. gallinae*. But due to the development of resistance against these mites, their efficiency is reduced, and farmers are compelled to utilize unauthorized drugs, that not only affect human health but also damages layer egg production and quality (Gokbulut et al., 2019; Pugliese et al., 2019; Decru et al., 2020; Katsavou et al., 2020; Wang et al., 2020). Apart from drugs, various types of acaricides have been used like Amitraz, Thiamethoxam, Fenitrothion, Clothianidin, and Milbemectin. But because of repeated use, resistance has been developed that limits their efficiency (Lee et al., 2017; Baran et al., 2020), that causes serious issues in the poultry industry (Lee et al., 2017). Further, they also have detrimental effects on the environment (Baran et al., 2020). Apart from these, some drugs and acaricides showed their effect against *D. gallinae* (Baran et al., 2020; Jian et al., 2022). But there is a dire need to find some alternatives for future use, in case of synthetic drugs and acaricidal failure (Alimi et al., 2021). That's why research is going on to find safe, good-quality alternatives both for the environment and the poultry industry (Al-Snafi, 2016; Mustafa et al., 2024).

Due to these problems, attention has been diverted towards natural acaricidal products against mites (Liao et al., 2023). These products are obtained from different sources, especially from plants (Nagarajan et al., 2021; Pares et al., 2021). Plant extracts are applied as acaricides due to the presence of alkaloids, tannins, phenols, flavonoids, and terpenoids. Because these compounds cause ovicidal, repellent, and mortality. Further, acaricidal plants also decrease the harmful effect of synthetic acaricides on the environment and are cost-effective (Castro et al., 2019; Pares et al., 2021). Because of various kinds of sources, structures, components, and less resistance chances, these compounds are mostly applied (Nagarajan et al., 2021; Velázquez-Antunez et al., 2023; Mustafa et al., 2024; Mustafa et al., 2024a). In this chapter, we will discuss the dose rate, type of extracts, and their effect on *D. gallinae*. Mode of action and importance of these plant extracts. Economic importance of *D. gallinae*. This chapter also discusses the zoonotic importance of these mites and limitations of these acaricidal plant extracts.

Economic Importance of *D. gallinae*

D. gallinae infestation was recorded in an egg production farm in Tunisia (Alimi et al., 2021), a lying hen farm in Iran (Ghavami et al., 2020; Tabari et al., 2020), a commercial laying farm in Brazil (Pares et al., 2021), and Ross 308 laying hens of Yemen (Al-Shaibani et al., 2021). It is also seen in 5400 hens on free-range farms and 42400 hens on aviary farms in Europe (Petersen et al., 2021). According to one study, *D. gallinae* infected chickens decreases their 32.1% live weight as compared to healthy ones and these infected chickens were died before 59 weeks of age. In healthy chickens, slowly increased in live weight (1.4-2.2 kg) occur from 15-34 weeks of age. While, infected chickens showed an increase in weight (1.3-1.9 kg) at the same time that slowly reduced from 34^{th} weeks of age. Infected chickens' survival rate was 24.9%, during the experiment, which is lower than the healthier ones (Yevstafieva & Petrunenko, 2024). According to Pavićević et al. (2021) cost of suppression of *D. gallinae* in layers is 60-euro cents/year. Apart from poultry, it is also seen to infect humans and cause gamasoidosis in different areas of the world (Sioutas et al., 2021; Barlaam et al., 2022). For different viral and bacterial diseases, it also acts as a vector and reservoir (Mustafa & Alsayeqh, 2025).

Zoonotic Importance of *D. gallinae*

D. gallinae also has zoonotic importance because it acts as a vector and reservoir of important zoonotic disease pathogens (Sigognault Flochlay et al., 2017; Mellou et al., 2021). Such as *Borrelia burgdorferi* and *avian influenza* A virus, are also important from zoonotic point of view (George et al., 2015). One of them is salmonella which is a causative agent of salmonellosis. *Salmonella enteritidis* is a causative agent of nontyphoidal salmonellosis (Mellou et al., 2021). *S. enteritidis* causes illness in humans through eggs or meat (Zhang et al., 2021). Egg contamination occurs by vertical (vitelline membrane, albumen, and yolk) and horizontal (eggshell perforation from the colonized gastrointestinal tract) routes (Cardoso et al., 2021; Liu et al., 2023). Salmonella species live within *D. gallinae* which plays a major role in its transmission (Cocciolo et al., 2020). Crushed mites or their blood is ingested by chickens orally. In this way, chickens act as a primary source of infection (Cocciolo et al., 2020). In humans, *D. gallinae* causes gamasoidosis (Barlaam et al., 2022).

Importance and Need of Plant Extracts

Concentrated materials obtained from plants that can be in different forms (solid, liquid, viscous) are known as plant extracts (Abubakar & Haque, 2020; Al-Saeed et al., 2023). They are obtained by extracting active ingredients from different plant parts (leaves, flowers, fruits, seeds, bark, or roots) by using water, alcohol, or plant-based oil as a solvent (Abubakar & Haque, 2020; Jian et al., 2022; Al-Saeed et al., 2023). These phytochemicals/active ingredients are extracted by using different methods (Abubakar & Haque, 2020), as shown in Figure 1. In phytochemicals, secondary metabolites (steroids, phenols, terpenoids, alkaloids, flavonoids, glucosides, saponins, and tannins) are most important (Lahare et al., 2021). Because of their unique properties such as, antiparasitic, antimicrobial, antiproliferative, antioxidant, antidiabetic, anti-inflammatory, anti-atherogenic, and analgesic, these are commonly used (Mihaylova et al., 2024). Plant extracts have gained importance in various fields of life (Ghavami et al., 2020; Al-Saeed et al., 2023; Plaskova & Mlcek, 2023). Properties and concentration of extracts vary due to different factors like extraction procedure, plant species, parts, and growth stage (Widowati et al., 2022; Jian et al., 2022). These extracts also have less chance of resistance, are economical, and are environmentally safe (Soni et al., 2021).

Fig. 1: Plant extraction procedures

Plant extracts are also used in veterinary parasitology (Zitterl-Eglseer & Marschik, 2020), especially against *D. gallinae* (Aziza et al., 2020) because of their different mechanisms of actions, as shown in Figure 2. These extracts also give better results than synthetic compounds (Ghavami et al., 2020). For example, Ivermectin at 100mg/mL causes 100% adult red mite mortality, while ethanolic extract of *L. Artemisia's* and S. *aromaticum* extract causes 100% mortality at 1mg/ml (Jian et al., 2022). *T. ammi* also causes 100% red mite mortality (Baran et al., 2020).

Some secondary metabolites are discussed here because of their acaricidal effects against *Dermanyssus gallinae* (Alimi et al., 2021). Like, Tannins are mainly found in leaf, leafage, and seed coverings of plants (Gonzaga et al., 2021). Tannins are of two types; hydrolyzable and condensed tannins (Chen et al., 2021). However, the level of condensed tannins is higher in plants than hydrolyzable tannins and also contains flavonoid units associated with carbon-carbon bonds (Sallam et al., 2021). They also enhance the immune system and passive immunity of animals (Neha et al., 2019; Abbas et al., 2021). These compounds also have a defense mechanism against herbivores and insects in plants (Hassanpour et al., 2011). Tannins are also commonly used in veterinary parasitology (Guneidy et al., 2021), especially against *Dermanyssus gallinae* because of their acaricidal effects (Tabari et al., 2020). Flavonoids are secondary metabolites, present in fruit, leaves, stems, flowers, seeds, and vegetables of plants (Feliciano et al., 2015). These are found in different types like flavones, flavanones, flavanonols, isoflavonoids, anthocyanidins, and chalcones (Panche et al., 2016). Due to various biological activities, these are mostly used against different diseases (Ullah et al., 2020). These are commonly used against *Dermanyssus gallinae* for acaricidal effects (Alimi et al., 2021).

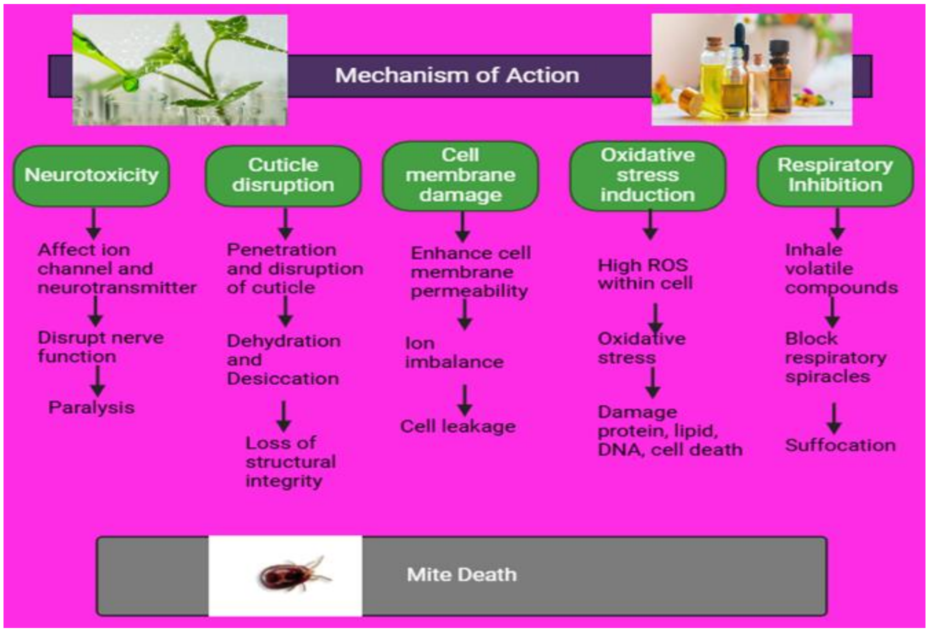

Fig. 2: Mechanism of action of the acaricidal effect of plant extracts against *Dermanyssus gallinae*

Effect of Plant Extracts against *D. gallinae*

Botanical compounds and their extract have potent activity against multiple pathogens (Abbas et al., 2025). The acaricidal effect of different plant extracts on *D. gallinae* depends upon the plant type, extraction procedure, amount and type of different compounds (thymol) especially, secondary metabolites (tannins, phenols, flavonoids, and phenylpropanoids) in it (Alimi et al., 2021). Some of them will be discussed here. *X. emarginata's* methanol eliminated dichloromethane-soluble part showed their acaricidal effect because of the existence of secondary metabolites (S. M) (Pares et al., 2021). This extract can show a harmful effect against *D. gallinae* because of the combined efficiency of various components (Tak and Isman, 2017; Pandiyan et al. 2019). Stem and bark extract of *X. sericea* is more active than fruit extract may be because of the composition and different levels of S. M in various parts of plants (Sameh et al., 2019; Wang et al., 2019). Jian et al. (2022) examined that ethanol extract of S. *aromaticum, C. cassia, L. Artemisia, H. syriacus, I. verum,* and *Taraxacum sp.* are effective against *D. gallinae*. However, *S. aromaticum* showed the best acaricidal effect (1mg/mL gave 100% mortality) than the other extracts (Jian et al., 2022). Moreover, *Illicium verum* has flavonoid (0.76mg/mL), tannin (0.12mg/mL), and phenolic (64.00mg/ml) components. These secondary metabolites showed their effect against *D. gallinae* (Jian et al., 2022). Cyclohexane and acetone extract of *L. nobilis* are less effective than ethanol extract (Alimi et al., 2021). As a result, plant secondary metabolites showed their effect against *D. gallinae* in poultry as shown in Table 1.

Combined Effect of Plant Extracts

According to some studies, the combined effects of different plants also give their best acaricidal effect against *D. gallinae* in poultry (Pares et al., 2021), as shown in Table 2. Like, the additive effect of *S. aromaticum* LC_{90} - *I. verum* LC_{90}, *I. verum* LC_{90} - *L. Artemisia* LC_{90}, *I. verum* LC_{90} - *L. Artemisia* LC_{50} extracts. Apart from this additive effect, some extracts also have antagonistic effects e.g., *S. aromaticum* LC_{50} - *L. Artemisia* LC_{90}, *I. verum* LC_{50} - *L. Artemisia* LC_{90}, and *I. verum* LC_{50} - *L. Artemisia* LC_{50} (Jian et al., 2022). Their acaricidal effect is due to the presence of phenols and flavonoids' combined effect in their ethanolic extracts. The combined effect of these plant extracts also has a toxic effect on different life cycle phases like egg, adult, nymph, and larvae due to polyphenol, tannin and flavonoids (Jian et al., 2022). Moreover, *X. sericea* - *D. lanceolata* extract showed 53% mortality of *D. galline* in poultry (Pares et al., 2021). In another study, 0.25% Allisal (garlic oil+ rosehip oil+ rapeseed oil+ polysorbate) have acaricidal effect against *D. gallinae* in poultry (Aziza et al., 2020). Plant oils that have minimal chemical components are less active than high chemical components (Aziza et al., 2020).

Limitation of Medicinal Plants

Undoubtedly, due to acaricidal and repellent properties, medicinal plants have become potential weapons against ectoparasites (Tabari et al., 2020). Due to the effectiveness of different compounds, it is less toxic to human health and the environment, making medicinal plants necessary for research (Baran et al., 2020). Recent research has brought phytochemical-based products into the market (Aziza et al., 2020). Few plant-based products are showing their harmful effects on humans and animals (Whitney et al., 2013; George et al., 2014). Moreover, some plants take time to growth, have difficulty in their cultivation, possibility of diseases, and cannot grow commercially (Appiah et al., 2018;

Nwafor et al. 2021; Shreedevasena et al. 2024). Some bioassays are used for the testing of acaricidal plant extracts like contact, vapor phase, and petri dish bioassays. Although these are simple, quick, and easy to use but these have some limitations. Such as in contact bioassay, animals may be immersed in acaricidal solutions which is why they cannot be used in the field. Vapor phase bioassay is only used for volatile substances and essential oils and cannot be applied as a contact repellant. While the high level of repellants can quickly fill the Petri dish's air space in the petri dish bioassay (Adenubi et al., 2018; Tabari et al., 2020; Pares et al., 2021). However, beyond regulatory concerns, currently, there are no specified techniques for extraction of chemical compounds or ectoparasite testing (Quadros et al., 2020). More funding is required to overcome the intricacy of field tests. Researches are required for the evaluation of synergistic/antagonistic impacts of medicinal plant extracts. Potential adverse impacts can be decreased by the laws involving ecotoxicity evaluations, possible collateral impacts and awareness about the potential risks associated with applying these compounds (Quadros et al., 2020).

Table 1: Acaricidal effect of different plant extracts and their compounds against *Dermanyssus gallinae* in poultry

Plants/plant parts	Extraction type	Sample collection from farms	Extract contains acaricidal compound	Results (% mortality)	References
Syzygium aromaticum (Flower bud)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	100 at 1mg/mL and 48h	Jian et al., 2022
Hibiscus syriacus (flowers)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	98.82 at 1mg/mL and 48h	Jian et al., 2022
Cinnamomum cassia (bark)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	60 at 1mg/mL and 48h	Jian et al., 2022
Taraxacum sp. (whole plant)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	90 at 1mg/mL and 48h	Jian et al., 2022
Xylopia emarginata (stem bark)	Methanol, Dichloromethane	Layer	Not mentioned	72 at 48h	Pares et al., 2021
Xylopia sericea (stem bark)	Methanol, Dichloromethane	Layer	Not mentioned	65	Pares et al., 2021
Laurus nobilis (leaves)	Ethanol	Egg production	Phenol, Flavonoid, Tannin	72.33±3.21 at 160mg/mL and 12h	Alimi et al., 2021
Laurus nobilis (leaves)	Ethanol	Egg production	Phenol, Flavonoid, Tannin	81±4.63 at 320mg/mL and 12h	Alimi et al., 2021
Laurus nobilis (leaves)	Ethanol	Egg production	Phenol, Flavonoid, Tannin	84±2.65 at 160mg/mL and 24h	Alimi et al., 2021
Laurus nobilis (leaves)	Ethanol	Egg production	Phenol, Flavonoid, Tannin	97.33±1.53 at 320mg/mL and 24h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	38.65±0.77 at 160mg/mL and12h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	42.44±2.00 at 320mg/mL and12h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	53.44±1.70 at 160mg/mL and 24h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	67.92±2.66 at 320mg/mL and 24h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	23.51±0.66 at 160mg/mL and 12h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	34.17±0.23 at 320mg/mL and 12h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	33.94±0.83 at 160mg/mL and 24h	Alimi et al., 2021
Laurus nobilis (leaves)	Acetone	Egg production	Phenol, Flavonoid, Tannin	46.12±0.20 at 320mg/mL and 24h	Alimi et al., 2021
Laurus nobilis (leaves)	Cyclohexane	Egg production	Phenol, Flavonoid, Tannin	33.94±0.83 at 160mg/mL at 24h	Alimi et al., 2021
Laurus nobilis (leaves)	Cyclohexane	Egg production	Phenol, Flavonoid, Tannin	46.12±0.20 at 320mg/mL 24h	Alimi et al., 2021
Ferula assafoetida (aerial parts)	Ethanol	Layer	Phenol, Flavonoid	lethal at 41.22±0.32, 128µg/cm^3	Rahali et al., 2019; Ghavami et al., 2020
Ferula assafoetida (aerial parts)	Ethanol	Layer	Phenol, Flavonoid	lethal at 39±1, 64µg/cm^3	Rahali et al., 2019; Ghavami et al., 2020

Table 2: Combined effects of different plant extracts and their secondary metabolites against *Dermanyssus gallinae* in poultry

Plants/plant parts	Extraction type	Sample collection from farms	Secondary metabolites	Results (% mortality)	References
Illicium verum LC_{50} + *Leonurus Artemisia* LC_{50} (Ripe fruit + whole plant)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	41.83	Jian et al., 2022
Illicium verum LC_{50} + *Leonurus Artemisia* LC_{90} (Ripe fruit + whole plant)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	60.01	Jian et al., 2022
Illicium verum LC_{90} + *Leonurus Artemisia* LC_{90} (Ripe fruit + whole plant)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	96.55	Jian et al., 2022
Illicium verum LC_{90} + *Leonurus Artemisia* LC_{50} (Ripe fruit + whole plant)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	86.33	Jian et al., 2022
Syzygium aromaticum LC_{90} + *Illicium verum* LC_{90} (Flower bud + Ripe fruit)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	87.64	Jian et al., 2022
Syzygium aromaticum LC_{90} + *Leonurus Artemisia* LC_{90} (Flower bud + Whole plant)	Alcohol	Egg	Phenolics, Flavonoids, Tannins	64.49	Jian et al., 2022
Xylopia sericea + *Duguetia lanceolata* (Fruits, Stem bark)	Methanol, Dichloromethane	Layer	Not Mentioned	53	Pares et al., 2021

Conclusion

Plant extracts give the best acaricidal effects against *D. gallinae*. Although these extracts are used single or combined. Some of them give 90-100% mortality of *D. gallinae* at different dose rates. Moreover, these extracts are toxic-free and safe for the environment. However, acaricidal plants have some limitations. Like, animals can immerse themselves by using contact bioassays and cannot be applied as contact repellant by using vapor phase bioassays. Moreover, there are no specified techniques for the extraction of chemical compounds. Further, some plants are growing slowly and have the possibility of disease and pests. Therefore, there is a need to find the exact dose, find new safe and effective extracts, and cultivate acaricidal plants against *D. gallinae* in poultry.

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