



# Evaluation of some additive agents in suppressing mold growth in phytoseiid rearing medium: effects on *Amblyseius swirskii* and *Transeius wainsteini* (Acari: Phytoseiidae)

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## ABSTRACT

The successful rearing of predators and parasitoids is crucial for the effectiveness of biological control programs. A notable challenge in rearing phytoseiid mites, specifically *Amblyseius swirskii* and *Transeius wainsteini*, is preventing mold contamination in their diets. This study evaluated the efficacy of three herbal powders, thyme, green tea, and lemongrass, as well as the chemical agent, calcium propionate, in suppressing mold development. Experiments were conducted using a diet composed of cattail pollen and rice husks under controlled laboratory conditions ( $25 \pm 1$  °C,  $65 \pm 5\%$  RH, and 16L: 8D h photoperiod). A diet without any additive agents served as the control. To quantify mold growth within each rearing unit, a numerical index, the Mold Contamination Index (MCI), ranging from 0 to 4 was employed. The results demonstrated that calcium propionate was significantly more effective than the other treatments, achieving complete inhibition of mold development (MCI = 0), compared to the control treatment (MCI = 1.45 and 1.40 for *A. swirskii* and *T. wainsteini*, respectively). The incorporation of calcium propionate into the diet significantly enhanced population growth rates, reaching 31.95% for *A. swirskii* and 23.57% for *T. wainsteini*, compared to the control treatments, which showed increases of only 2.3% and 1.74%, respectively, over one month. In contrast, the addition of botanical powders did not inhibit mold growth and was associated with a decrease in population growth rates relative to the controls. The mixture of cattail pollen, rice husks, and calcium propionate provided sufficient nutritional support, facilitating population growth of both mite species. Consequently, the populations expanded to a total of 494.3 and 368.6 individuals across all developmental stages, originating from an initial density of 15 adult mites, within one month for *A. swirskii* and *T. wainsteini*, respectively. This study presents a promising strategy for managing mold in phytoseiid mite diets, ultimately fostering healthier rearing conditions.

## KEYWORDS

Calcium propionate, herbal powder, mass rearing, mold growth, phytoseiid mites

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## INTRODUCTION

Mass rearing of biocontrol agents is crucial for the success of biological control programs, as it facilitates the production of large quantities of beneficial organisms to manage pests and support integrated pest management (IPM) strategies (Parra 2008). The effectiveness of mass rearing is assessed by its capacity to rapidly produce substantial numbers of these agents in a cost-efficient manner (Leppla 2023). Additionally, the released biocontrol agents must demonstrate high field efficacy to ensure effective pest suppression (van Lenteren 2003). Therefore, providing appropriate rearing environments



is essential for the successful mass production of biocontrol agents (van Lenteren *et al.* 2004). Providing contaminant-free diets is essential, as pollutants and fungal contamination can reduce health, reproduction, and performance of the agents (Nordlund 1998).

Phytoseiid mites play a crucial role as biological control agents in managing various plant pests (Yeşilayer 2021). *Amblyseius swirskii* Athias-Henriot (Acari: Phytoseiidae), a generalist phytoseiid mite, has gained significant recognition as a commercial biological control agent for reducing whitefly and thrips populations in diverse greenhouse crops (Nomikou *et al.* 2001; Messelink *et al.* 2006; Calvo *et al.* 2011). *Transeius wainsteini* (Gomelauri) (Acari: Phytoseiidae) was first identified in northwest Iran (Rahmani *et al.* 2010). Moreover, this species has been recognized as a significant component of phytoseiid populations in Iranian citrus orchards, accounting for 30.6% of the overall phytoseiid community (Hajzadeh and Nazari 2012). *Transeius* spp. are generalist with demonstrated potential in pest control across various crops (Téllez *et al.* 2020; Castañé *et al.* 2022; Meshkov *et al.* 2024). The generalist phytoseiids exhibit a versatile diet, preying on diverse arthropods while also consuming plant materials such as pollen and honeydew (Momen and El-Saway 1993). Pollen grains serve as a particularly effective food source in the rearing of these predatory mites, enhancing their efficacy as a biological control agent (Nguyen *et al.* 2013; Kumar *et al.* 2014; Khanamani *et al.* 2017a; Hadadi *et al.* 2022).

A significant challenge in rearing phytoseiid mites is mold development in their diet, which is primarily composed of pollen (Yari *et al.* 2024). Fungal proliferation can degrade the nutritional quality of their food, endanger the mites' health, and ultimately impair their population growth and efficacy as biological control agents (Bjørnson 2008). Consequently, it is essential to regularly remove or sanitize feeding substrates, a practice that can increase labor requirements, operational costs, and the complexity of maintaining optimal rearing conditions. Spice plants made into powder were widely used by ancient civilizations to improve the palatability of foods and beverages as well as for their preserving characteristics (Daoud *et al.* 1990; Anwar *et al.* 1992; Evans 2009; Poswal *et al.* 1993). The use of plants or plant-derived products as fungicides is of significant importance and warrants further attention (Bodde 1982). *Thymus vulgaris* L. (Lamiales: Lamiaceae), commonly known as thyme, exhibits potent antifungal properties, especially against molds, largely due to its high thymol content, a key component of its essential oil. Thymol has been demonstrated to inhibit the growth of various fungi (Šegvić Klarić *et al.* 2007). *Camellia sinensis* (L.) (Theales: Theaceae), the plant that produces green tea, contains compounds with antifungal activity. Notably, polyphenols such as catechins can inhibit the growth and development of numerous fungi (Aboulwafa *et al.* 2019). Among the many species and varieties within the genus *Cymbopogon*, *C. citratus* (Poales: Poaceae) (lemongrass) is particularly cultivated for its essential oil, which is widely used in cosmetics, perfumery, and the food industry. The essential oil of *C. citratus* exhibits significant antifungal properties and has potential as a biopreservative. It has been shown to inhibit the growth of various fungi (Kieltyka-Dadasiewicz *et al.* 2024). Propionic acid (CH<sub>3</sub>CH<sub>2</sub>-COOH), an organically occurring amino carboxylic acid, is a viscous liquid characterized by a slightly pungent, rancid odor (Doores 1993). Its acid form and salts are commonly used to inhibit bacterial spoilage and fungal contamination (Legan 1993). Calcium propionate, in particular, is employed in food preservation as an anti-mold agent, effectively inhibiting mold growth and extending the shelf life of products such as bread and baked goods (Heflich 2021). It exerts its antifungal effect by interfering with the metabolic processes of microorganisms, thereby preventing them from producing the energy necessary for growth and reproduction (Brock and Buckel 2004).

Given the explanations above and the critical importance of maintaining a healthy phytoseiid rearing culture, no anti-mold agent has yet been established that both inhibits mold growth and has no adverse effect on the development of predatory mites. Consequently, this study evaluated the efficacy of several additive agents: thyme powder, green tea powder, lemongrass powder, and calcium propionate, in inhibiting mold growth within a diet composed of cattail pollen and rice husks in *A. swirskii* and *T. wainsteini* rearing units.

## MATERIAL AND METHODS

All experiments in this study were conducted at the Department of Agricultural Zoology, Iranian Research Institute of Plant Protection (IRIPP), Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran.

### **Pollen collection**

Cattail (*Typha latifolia* L.) pollen was gathered from the male inflorescences of cattail plants in Mahallat, Markazi Province, Iran. The collected pollen grains were subsequently dried at 25 °C for 36 hours. The pollen grains were stored at 4 °C for daily usage or frozen at -20 °C for prolonged preservation.

### **Preparation of additive agents**

Specimens of thyme (*Thymus vulgaris*), green tea (*Camellia sinensis*), and lemongrass (*Cymbopogon citratus*) were harvested from Guilan, Markazi, and Fars Provinces in Iran. After thorough cleaning, the plant materials were air-dried over one week under ambient environmental conditions, and then their leaves were ground into a fine powder. The chemical antifungal agent, calcium propionate, was obtained from Petrokimia Company in Iran. To maintain its efficacy and ensure quality, the anti-mold agent was stored at 4 °C, facilitating its daily application.

### **Stock colonies of phytoseiids**

The stock colony of *A. swirskii* was obtained from the Iranian Research Institute of Plant Protection. *Transeius wainesteini* was collected from *Rhamnus cathartica* L. in Rasht City (Guilan Province, Iran) identified by Dr. Serge Krieter (Emeritus Professor at Institut Agro Montpellier Montferrier-sur-Lez, Languedoc-Roussillon, France). The phytoseiids were reared for 5 generations in the system described by Yari *et al.* (2024). The rearing system consisted of a Petri dish (8 cm in diameter) placed on a water-saturated sponge in a plastic box (16 × 12 × 6 cm) containing water. A fresh diet composed of *Tyrophagus putrescentiae* (Schrank) (10 live individuals from immature stages), cattail pollen (0.050 g), and rice husk (0.200 g) was added to the rearing arena every two days. The weighing of diet materials was performed using a digital scale (GR 300, Co., Ltd., Japan) to a precision of 0.001 g. The stock colonies were kept at 25 ± 1 °C, 65 ± 5% RH, and a photoperiod of 16L:8D h.

### **Stock colony of *T. putrescentiae***

The initial stock of *T. putrescentiae* was obtained from the Iranian Research Institute of Plant Protection. The colony was subsequently maintained and propagated following the rearing system outlined by Yari *et al.* (2024). A diet consisting of yeast granules (0.200 g) and rice husks (0.200 g) was provided as a food source. The stock colonies of *T. putrescentiae* were maintained under the same laboratory conditions as the phytoseiids' colonies.

### **Experimental setup**

Each experimental unit consisted of a Petri dish (8 cm in diameter) placed on a water-saturated sponge inside a plastic container (16 × 12 × 6 cm). To evaluate the effectiveness of the additive agents in preventing mold growth, the mold growth rate per rearing unit and the final populations (all life stages) of the phytoseiid mites after a month were quantified as an indicator of a healthy rearing environment.

Initially, 15 three-day-old adult predatory mites (10 females and 5 males) were released on each experimental unit which contained a diet of cattail pollen (0.050 g) and rice husk (0.200 g). Different agents (herbal powders of thyme, green tea, and lemongrass, and calcium propionate) were also added (0.050 g) to each experimental unit, at a concentration of 20% w/w. The experimental setup without the inclusion of the additive agents was considered the control treatment. Fresh diet and additive agents were introduced to the experimental units by direct mixing at regular three-day intervals. To evaluate the efficacy of various anti-mold agents, the mold growth rate in each rearing unit was assessed, and the final population densities (all life stages) of the predatory mites per experimental unit after a month were counted under a stereomicroscope (Meiji Techno Co. Ltd, Japan). Each treatment had 10 replications, randomly placed in a growth chamber. All experiments were performed in a growth room at 25 ± 1 °C,

65 ± 5% RH, and 16L:8D photoperiod.

### Data analysis

To quantify mold growth within each rearing unit, a numerical index, the Mold Contamination Index (MCI), ranging from 0 to 4 was employed: 0 indicating no mold presence; 1 representing mold coverage of ≤ 25%; 2 indicating 25–50% coverage; 3 reflecting 50–75% coverage; and 4 signifying complete mold coverage (75–100%) in the rearing environment.

To calculate the population growth rate of phytoseiid mites, the following formula was employed:

$$R = \frac{N_t - N_0}{N_0} \times 100$$

R,  $N_t$ , and  $N_0$  represent the population growth rate percentage, the final population density, and the initial population density ( $N_0$ ), respectively.

Analysis of mold growth rate (MCI) per rearing unit, as well as the percent of population growth rate and final population densities (across all stages) of *A. swirskii* and *T. wainsteini* fed on diets combined with various additive agents, was conducted using a factorial design with phytoseiid species and additive agents as the main factors. All statistical analyses were performed using SAS version 9.4 TS Level 1M6. The General Linear Model (GLM) procedure was used to evaluate the effects of different anti-mold agents added to the diet on MCI, the growth rate of phytoseiids, and their final population density.

## RESULTS

Results indicated that there was no significant interaction between mite species and anti-mold agents on the level of contamination ( $P = 0.99$ ). Mold Contamination Index (MCI) did not differ significantly between the rearing units of the two predatory mite species ( $P = 0.42$ ). The addition of calcium propionate to the diet effectively prevented mold development in the rearing units of both predatory mite species. Subsequently, the lowest mold growth was observed in the control treatment, followed by the green tea treatment. The highest mold contamination was recorded with the addition of lemongrass, followed by thyme, without a significant difference (Table 1).

**Table 1.** The Mold Contamination Index (MCI) of *Amblyseius swirskii* and *Traneisus wainsteini* rearing units in different treatments of additive agents.

Additive agent	Mold Contamination Index (MCI)	
	<i>A. swirskii</i>	<i>T. wainsteini</i>
Calcium propionate	0.0 ± 0.0 <sup>d</sup>	0.0 ± 0.0 <sup>d</sup>
Thyme	3.50 ± 0.16 <sup>a</sup>	3.30 ± 0.21 <sup>a</sup>
Green tea	2.70 ± 0.26 <sup>b</sup>	2.60 ± 0.26 <sup>b</sup>
Lemongrass	3.80 ± 0.13 <sup>a</sup>	3.70 ± 0.15 <sup>a</sup>
Control	1.50 ± 0.26 <sup>c</sup>	1.40 ± 0.26 <sup>c</sup>

Means followed by different small letters in the column show the significant differences (Tukey's test;  $P < 0.05$ )

The results of the GLM revealed that the interaction effect of mite species × anti-mold agent on population growth rate of the phytoseiids was significant ( $P < 0.001$ ) (Table 2). Incorporation of calcium propionate into the diet significantly enhanced the population growth rates to 31.95% for *A. swirskii* and 23.57% for *T. wainsteini*, compared to the control treatments (2.3% and 1.74%, respectively). In contrast, the addition of botanical powders did not prevent mold growth and was associated with a decrease in population growth rates relative to controls (Table 2).

**Table 2.** The percentage of population growth rate (total stages) of *Amblyseius swirskii* and *Transeius wainsteini* fed on cattail pollen and rice husk combined with different additive agents after a month

Species	Additive agents	Population growth rate (%)
<i>A. swirskii</i>	Calcium propionate	31.95 ± 1.01 <sup>a</sup>
	Thyme	-0.39 ± 0.06 <sup>d</sup>
	Green tea	-0.30 ± 0.05 <sup>d</sup>
	Lemongrass	-0.84 ± 0.03 <sup>d</sup>
	Control	2.3 ± 0.42 <sup>c</sup>
<i>T. wainsteini</i>	Calcium propionate	23.57 ± 0.76 <sup>b</sup>
	Thyme	-0.49 ± 0.05 <sup>d</sup>
	Green tea	-0.40 ± 0.04 <sup>d</sup>
	Lemongrass	-0.8 ± 0.03 <sup>d</sup>
	Control	1.74 ± 0.35 <sup>c</sup>

Means followed by different small letters in the column show the significant differences (Tukey's test;  $P < 0.05$ )

Adding calcium propionate to the diet resulted in a substantial increase in population across all life stages of the phytoseiids, surpassing the outcomes observed in other treatments ( $P < 0.001$ ; Table 3). *Amblyseius swirskii* grew better than *T. wainsteini* on the mixture of cattail pollen, rice husk, and calcium propionate ( $P < 0.001$ ) (Table 3). The final population densities (total stages) of *A. swirskii* and *T. wainsteini* on the mixture of cattail pollen, rice husks, and calcium propionate were 494.3 and 368.6 after a month, respectively (Table 3). The incorporation of thyme powder, green tea powder, and lemongrass powder did not significantly reduce mold growth and led to an unexpected increase in mold proliferation within the phytoseiid-rearing units. Consequently, this resulted in a decline in *A. swirskii* and *T. wainsteini* populations compared to the control treatments (Table 3).

**Table 3.** The final population densities of different life stages of *Amblyseius swirskii* and *Transeius wainsteini* fed on a combination of cattail pollen and rice husks with various additive agents over a month.

Species	Additive agents	egg	larvae	Protonymp	Deutonymph	Adult	Adult male	Total
<i>A. swirskii</i>	Calcium propionate	39.3±1.2 <sup>a</sup>	44.2±1.35 <sup>a</sup>	19.5±0.6 <sup>a</sup>	14.4±0.47 <sup>a</sup>	312.7±9.58 <sup>a</sup>	64.2±2 <sup>a</sup>	494.3±15.22 <sup>a</sup>
	Thyme	1.7±0.3 <sup>cd</sup>	0.9±0.23 <sup>cd</sup>	0.4±0.16 <sup>cd</sup>	0.2±0.13 <sup>cd</sup>	4.4±0.3 <sup>d</sup>	1.5±0.22 <sup>cd</sup>	9.1±0.91 <sup>d</sup>
	Green tea	2±0.29 <sup>cd</sup>	0.9±0.23 <sup>cd</sup>	0.5±0.16 <sup>cd</sup>	0.3±0.15 <sup>cd</sup>	5±0.25 <sup>d</sup>	1.7±0.21 <sup>cd</sup>	10.4±0.76 <sup>d</sup>
	Lemongrass	0.4±0.16 <sup>c</sup>	0.0±0.0 <sup>c</sup>	0.0±0.0 <sup>c</sup>	0.0±0.0 <sup>d</sup>	1.5±0.37 <sup>d</sup>	0.5±0.16 <sup>d</sup>	2.4±0.49 <sup>d</sup>
	Control	5.3±0.51 <sup>c</sup>	4.2±0.57 <sup>c</sup>	2.1±0.48 <sup>c</sup>	1.4±0.45 <sup>c</sup>	32.7±4.73 <sup>c</sup>	4.5±0.54 <sup>c</sup>	49.6±6.44 <sup>c</sup>
<i>T. wainsteini</i>	Calcium propionate	29.2±0.9 <sup>b</sup>	32.8±0.99 <sup>b</sup>	14.3±0.44 <sup>b</sup>	10.5±0.4 <sup>b</sup>	234.1±7.19 <sup>b</sup>	47.7±1.49 <sup>b</sup>	368.6±11.40 <sup>b</sup>
	Thyme	1.5±0.26 <sup>cd</sup>	0.8±0.2 <sup>cd</sup>	0.4±0.16 <sup>cd</sup>	0.2±0.13 <sup>cd</sup>	3.4±0.3 <sup>d</sup>	1.3±0.15 <sup>cd</sup>	7.6±0.77 <sup>d</sup>
	Green tea	1.5±0.26 <sup>cd</sup>	0.9±0.23 <sup>cd</sup>	0.5±0.16 <sup>cd</sup>	0.3±0.15 <sup>cd</sup>	4.2±0.44 <sup>d</sup>	1.5±0.22 <sup>cd</sup>	8.9±0.73 <sup>d</sup>
	Lemongrass	0.3±0.15 <sup>c</sup>	0.0±0.0 <sup>c</sup>	0.0±0.0 <sup>c</sup>	0.0±0.0 <sup>d</sup>	1.4±0.37 <sup>d</sup>	0.4±0.16 <sup>d</sup>	2.1±0.48 <sup>d</sup>
	Control	4±0.39 <sup>cd</sup>	3.2±0.51 <sup>cd</sup>	1.9±0.37 <sup>cd</sup>	1.1±0.34 <sup>cd</sup>	27.6±3.98 <sup>c</sup>	3.6±0.49 <sup>cd</sup>	41.1±5.30 <sup>c</sup>

Means followed by different small letters in the column show the significant differences (Tukey's test;  $P < 0.05$ )

## DISCUSSION

The findings of this research demonstrated that calcium propionate is an effective agent in inhibiting mold growth within the rearing environments of *A. swirskii* and *T. wainsteini*. The incorporation of the anti-mold agent, calcium propionate, into the rearing units of the phytoseiids proved advantageous in two ways. Firstly, it successfully prevented mold growth, ensuring a clean environment for the mites. Secondly, its presence did not have any adverse impact on the growth and development of the predatory mites, thereby maintaining its overall health and reproductive capacity. Similarly, calcium propionate has been used as a mold inhibitor in animal feed and fruit preservation (Paster *et al.* 1985; Guo *et al.* 2016). For example, in jujube fruit, calcium propionate inhibited spore germination of post-harvest pathogens and enhanced the biocontrol activity of *Metschnikowia pulcherrima* yeast, reducing disease incidence and

lesion development (Guo *et al.* 2016). Calcium propionate is widely used as a food preservative and feed additive, particularly in bakery products and dairy cow nutrition. It effectively inhibits microbial growth in food (Phechkrajang and Yooyong 2017). Propionate accumulates within cells and competes with alanine and other amino acids essential for microbial growth. Additionally, it inhibits enzymes vital to metabolic processes. Propionate is converted into propionyl-CoA, which subsequently inhibits CoA-dependent enzymes, including pyruvate dehydrogenase, succinyl-CoA synthetase, and ATP citrate lyase (Kagliwal *et al.* 2014). Therefore, Calcium propionate's ability to maintain a mold-free diet contributes to the overall health and performance of the predatory mites, ultimately supporting their successful mass production for use in biological control programs.

This study showed that none of the tested herbal powders (thyme, green tea, and lemongrass) exerted a significant inhibitory effect on mold growth within predatory mite rearing environments. Moreover, incorporating these substances into the diet adversely affected the growth of the predatory mites relative to the control treatment. Several studies have confirmed the acaricidal effects of plant extracts from thyme and lemongrass on mites, including *T. urticae* (Mead 2012; Ghamari *et al.* 2021). In contrast to our results, El-Mougy and Abdel-Kader (2007) found that thyme powder (*T. vulgaris*) significantly suppressed the growth and activity of faba bean damping-off disease. Additionally, previous research has documented that varying concentrations of mint, sage, bay leaf, anise, and red pepper powders significantly inhibited the growth of *Aspergillus parasiticus* (Karapinar 1985). Consistent with our findings, green tea powder (Matcha) has demonstrated antibacterial activity against both Gram-positive and Gram-negative bacteria, as well as yeast, without showing any antifungal effects (Edraki *et al.* 2022). Similarly, lemongrass essential oil has been shown to reduce spore germination in *Colletotrichum coccodes*, *Botrytis cinerea*, *Cladosporium herbarum*, and *Rhizopus stolonifer*, although it increased sporulation in *Aspergillus niger* (Tzortzakis and Economakis 2007). The antimicrobial activity of spices is influenced by numerous factors, including the type of spice, its chemical composition and concentration, the initial microbial load, substrate characteristics, processing conditions, and storage parameters (Shelef 1983; Farag *et al.* 1989). Studies have demonstrated that plant extracts generally exhibit stronger antifungal activity compared to their powdered counterparts (El-Mougy and Abdel-Kader 2007). Consequently, herbal powders derived from thyme, lemongrass, and green tea did not prevent mold growth in predatory mite breeding environments and, in fact, adversely affected their growth. Therefore, incorporating these powders as anti-mold additives in predatory mite diets is not recommended. Moreover, the adverse effects of these compounds on the predatory mites' biology complicate their use in integrated mite management (IMM), underscoring the need for further research. This research revealed that a combination of cattail pollen, rice husk, and calcium propionate serves as an optimal diet for *A. swirskii* and *T. wainsteini* rearing, yielding a remarkable 31.95% and 23.57% growth rate in the mite populations within a month, respectively. Previous studies demonstrated that pollen grains are an effective food source for successfully rearing generalist phytoseiids, specifically *A. swirskii* (Nguyen *et al.* 2013; Kumar *et al.* 2014; Hadadi *et al.* 2022). Pollen grains supply essential components such as proteins, lipids, sugars, and vitamins for predatory mites supporting their growth, development, and reproduction (Khanamani *et al.* 2017b). Rice husks are a good source of shelter for predatory mites and are useful for retaining moisture within the media (Hwang *et al.* 2019; Yari *et al.* 2024). Adding the anti-mold agent, calcium propionate, to the mixture of cattail pollen and rice husk provides a favorable diet for *A. swirskii* and *T. wainsteini*, thereby preventing mold growth in the rearing medium and promoting suitable growth for the predatory mite.

In conclusion, calcium propionate emerges as a highly effective anti-mold agent, providing a robust solution to the challenges posed by mold contamination in phytoseiid-rearing environments. By significantly reducing the risk of fungal growth in dietary supplies, calcium propionate enhances the overall quality of these environments. Additionally, given that only a small amount of this substance is required, approximately 20% w/w per rearing colony, it offers a cost-effective solution. This improvement facilitates more efficient mass production of phytoseiid predators, thereby ensuring a consistent and reliable supply essential for integrated pest management initiatives. However, the long-term effects of this substance on phytoseiids warrant further evaluation in future studies.

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## REFERENCES

- Aboulwafa, M.M., Youssef, F.S., Gad, H.A., Altyar, A.E., Al-Azizi, M.M. & Ashour, M.L. (2019) A comprehensive insight on the health benefits and phytoconstituents of *Camellia sinensis* and recent approaches for its quality control. *Antioxidants*, 8(10): 455. <https://doi.org/10.3390/antiox8100455>
- Anwar, T., Jabbar, A., Khaliq, F., Tahir, S. & Shakeel, M.A. (1992) Plants with insecticidal activities against four major insect pests in Pakistan. *Tropical Pest Management*, 38(4): 431–437.
- Brock, M. & Buckel, W. (2004) On the mechanism of action of the antifungal agent propionate. *European Journal of Biochemistry*, 271(15): 3227–3241. <https://doi.org/10.1111/j.1432-1033.2004.04255.x>
- Björnson, S. (2008) Natural enemies of mass-reared predatory mites (family phytoseiidae) used for biological pest control. *Experimental and Applied Acarology*, 46: 299–306. <https://doi.org/10.1007/s10493-008-9187-1>
- Bodde, T. (1982) Entomologists probe chemical defenses and natural enemies. *Bioscience*, 32: 308–311.
- Calvo, F.J., Bolckmans, K. & Belda, J.E. (2011) Control of *Bemisia tabaci* and *Frankliniella occidentalis* in cucumber by *Amblyseius swirskii*. *Biological Control*, 56(2): 185–192. <https://doi.org/10.1007/s10526-010-9319-5>
- Castañe, C., Alomar, O., Rocha, A., Vila, E. & Riudavets, J. (2022) Control of *Aculops lycopersici* with the predatory mite *Transeius montdorensis*. *Insects*, 13(12): 1116. <https://doi.org/10.3390/insects13121116>
- Daoud, A.S., Qasim, N.A. & Al-Mallah, N.M. (1990) Comparison study on the effect of some plant extracts and pesticides on some phytopathogenic fungi. *Mesopotamia Journal of Agriculture*, 22(4): 227–235. <https://doi.org/10.2478/intox-2014-0002>
- Doores, S. (1993) Organic acids. In: Davidson, P.M. & Branen, A.L. (Eds.), *Antimicrobials in Foods*. Marcel Dekker, Inc., New York, USA, pp. 117–119.
- Edraki, M., Mousazadeh Moghaddampour, I., Banimahd Keivani, M. & Sheydaei, M. (2022) Characterization and antimicrobial properties of Matcha green tea. *Chemical Review and Letters*, 5(1): 76–82. <https://doi.org/10.22034/crl.2022.324398.1147>
- Evans, C.W. (2009) *Treas and Evans pharmacognosy*. 16th ed. Saunders Elsevier, Edinburgh, New York, 603 pp.
- El-Mougy, N.S. & Abdel-Kader, M.M. (2007) Antifungal effect of powdered spices and their extracts on growth and activity of some fungi in relation to damping-off disease control. *Journal of Plant Protection Research*, 74(3): 267–280.
- Farag, R.S., Daw, Z.Y., Hewedi, F.M. & El-Baroty, G.S.A. (1989) Antibacterial activity of some Egyptian species essential oils. *Journal of Food Protection*, 52: 665–667. <https://doi.org/10.4315/0362-028X-52.9.665>
- Ghamari, M.J., Homayoonzadeh, M., Allahyari, H. & Talebi, K. (2021) Acaricidal activity of Shirazian

thyme and rosemary methanolic extracts in combination with spiroadiclofen and propargite on *Tetranychus urticae* (Acari: Tetranychidae). *Persian Journal of Acarology*, 10(4) : 481–489.

<https://doi.org/10.22073/pja.v10i4.69062>

Guo, D.Q., Wang, W.H., Pu, Y.F., Xu, Q., Zhu, L.X. & Yang, B.Q. (2016) Influence of calcium propionate on the control of post-harvest rots of jujube and the biocontrol activity of an antagonistic yeast. *Journal of Horticultural Science and Biotechnology*, 91(5): 435–440.

<https://doi.org/10.1080/14620316.2016.1155314>

Hadadi, A., Fathipour, Y., Hajiqanbar, H. & Riahi, E. (2022) Long-term effects of cattail pollen on development, population growth potential, and predation capacity of *Amblyseius swirskii* (Acari: Phytoseiidae). *Biocontrol Science and Technology*, 32(12): 1403–1416.

<https://doi.org/10.1080/09583157.2022.2134555>

Hajizadeh, J. & Nazari, M. (2012) A checklist and key for the phytoseiid mites (Acari: Phytoseiidae) of citrus orchards in Iran, with a new record for Iranian phytoseiid mites. *Systematic and Applied Acarology*, 17(4): 388–396. <http://www.bioone.org/doi/full/10.11158/saa.17.4.7>

Heflich, L. (2021) Calcium Propionate - Health Food? *Acta Scientifci Nutritional Health*, 5(8): 15–16.

<https://doi.org/10.31080/ASNH.2020.05.0903>

Hwang, H.S., Jung, D.O., Park, J. & Lee, K.Y. (2019) Simple mass-rearing technique of a predatory mite *Gaeolaelaps aculeifer* (Canestrini) (Acari: Laelapidae). *Entomological Research*, 49(12): 529–533.

<https://doi.org/10.1111/1748-5967.12399>

Karapinar, M. (1985) The effects of citrus oil and some Turkish spices on growth and aflatoxin production by *Aspergillus parasiticus* NRRL 2999. *International Journal of Food Microbiology*, 12: 239–245.

[https://doi.org/10.1016/0168-1605\(85\)90014-5](https://doi.org/10.1016/0168-1605(85)90014-5)

Kagliwal, L.D., Jadhav, S.B., Singhal, R.S. & Kulkarni, P.R. (2014) Preservatives: Permitted preservatives – Propionic acid, *In: Batt, C.A. & Tortorello, M.L. (Eds.), Encyclopedia of Food Microbiology*. 2<sup>nd</sup> Ed. Academic Press, pp. 99–101. <https://doi.org/10.1016/B978-0-12-384730-0.00270-6>.

Kieltyka-Dadasiewicz, A., Esteban, J. & Jabłńska-Trypuć, A. (2024) Antiviral, antibacterial, antifungal, and anticancer activity of plant materials derived from *Cymbopogon citratus* (DC.) stapf species. *Pharmaceuticals*, 17: 705. <https://doi.org/10.3390/ph17060705>

Khanamani, M., Fathipour, Y., Talebi, A.A. & Mehrabadi, M. (2017a) How pollen supplementary diet affect life table and predation capacity of *Neoseiulus californicus* on two-spotted spider mite. *Systematic and Applied Acarology*, 22(1): 135–147. <https://doi.org/10.11158/saa.22.1.14>

Khanamani, M., Fathipour, Y., Talebi A.A. & Mehrabadi M. (2017b) Evaluation of different artificial diets for rearing the predatory mite *Neoseiulus californicus* (Acari: Phytoseiidae): diet-dependent life table studies. *Acarologia*, 57(2): 407–419. <https://doi.org/10.1051/acarologia/20174165>

Kumar, V., Wekesa, V., Avery, P.B., Powell, C.A., McKenzie, C.L. & Osborne, L. (2014) Effect of different ornamental pepper pollen on the development and reproduction of *Amblyseius swirskii* (Acari: Phytoseiidae). *Florida Entomologist*, 97(2): 367–373.

<https://doi.org/10.1653/024.097.0205>

Mead, H. (2012) Acaricidal activity of lemongrass, *Cymbopogon citratus* essential oil against *Tetranychus urticae*. *Journal of Plant Protection and Pathology*, 3(1) : 43–51.

Messelink, G.J., van Steenpaal, S.E.F. & Ramakers, P.J.M. (2006) Evaluation of phytoseiid predators for control of western flower thrips on greenhouse cucumber. *Biological Control*, 51: 753–768.

<https://doi.org/10.1007/s10526-006-9013-9>

Meshkov, Y.I., Glinushkin, A.P. & Stepanova, E.V. (2024) Prospects for use of the predatory mite *Transeius herbarius* (Weinstein, 1960) (Mesostigmata: sam. Phytoseiidae, subfamily. Amblyseiinae). *BIO Web of Conferences*, 93: 01012. <https://doi.org/10.1051/bioconf/20249301012>

Momen, F.M. & El-Saway, S.A. (1993) Biology and feeding-behavior of the predatory mite, *Amblyseius swirskii* (Acari, Phytoseiidae). *Acarologia*, 34(3): 199–204. <https://doi.org/10.5555/19941103389>

- Nguyen, D.T., Vangansbeke, D., Lü, X. & De Clercq, P. (2013) Development and reproduction of the predatory mite *Amblyseius swirskii* on artificial diets. *Biological Control*, 58: 369–377.  
<https://doi.org/10.1007/s10526-012-9502-y>
- Nomikou, M., Janssen, A., Schraag, R. & Sabelis, M.W. (2001) Phytoseiid predators as potential biological control agents for *Bemisia tabaci*. *Experimental and Applied Acarology*, 25: 271–291.  
<https://doi.org/10.1023/A:1017976725685>
- Nordlund, D.A. (1998) Capacity and quality: Keys to success in the mass rearing of biological control agents. *Natural Enemies of Insects*, 20: 169–179. <https://doi.org/10.5555/19991102970>
- Legan, L.D. (1993) Mould spoilage of bread—the problem and some solutions. *International Biodeterioration and Biodegradation*, 32: 33–53. [https://doi.org/10.1016/0964-8305\(93\)90038-4](https://doi.org/10.1016/0964-8305(93)90038-4)
- Leppla, N.C. (2023) Concepts and methods of quality assurance for mass-reared parasitoids and predators. In: Morales-Ramos, J.A., Guadalupe Rojas, M. & Shapiro-Ilan, D.I. (Eds.), *Mass Production of Beneficial Organisms*. 2<sup>nd</sup> Ed. *Academic Press*, pp. 261–290.  
<https://doi.org/10.1016/B978-0-12-822106-8.00012-9>
- Parra, J.R.P. (2008) Mass rearing of natural enemies. In: Capinera, J.L. (Eds.), *Encyclopedia of Entomology*. Springer, Dordrecht. pp. 2301–2305. [https://doi.org/10.1007/978-1-4020-6359-6\\_1741](https://doi.org/10.1007/978-1-4020-6359-6_1741)
- Paster, N., Bartov, I. & Perelman, A. (1985) Studies of the fungistatic activity of antifungal compounds in mash and pelleted feeds. *Poultry Science*, 64(9): 1673–1677.  
<https://doi.org/10.3382/ps.064167310.3382/PS.0641673>
- Phechkrajang, C.M. & Yooyong, S. (2017) Fast and simple method for semiquantitative determination of calcium propionate in bread samples. *Journal of Food and Drug Analysis*, 25(2): 254–259.  
<https://doi.org/10.1016/j.jfda.2016.03.013>
- Poswal, M.A.T., Masunga, G., Javaid, I. & Kwerepe, B.C. (1993) Potential of different toxic and medicinal plant extracts for the control of fungal plant pathogens in Botswana. *Mededelingen van de Faculteit-Landbouwwetenschappen, Universiteit-Gent*, 58: 1373–1381.
- Šegvić Klarić, M., Kosalec, I., Mastelić, J., Piecková, E. & Pepeljnak, S. (2007) Antifungal activity of thyme (*Thymus vulgaris* L.) essential oil and thymol against moulds from damp dwellings. *Letters in Applied Microbiology*, 44: 36–42. <https://doi.org/10.1111/j.1472-765X.2006.02032.x>
- Shelef, L.A. (1983) Antimicrobial effects of spices. *Journal of Food Safety*, 6: 29–44.  
<https://doi.org/10.1111/j.1745-4565.1984.tb00477.x>
- Rahmani, H., Kamali, K. & Faraji, F. (2010) Predatory mite fauna of Phytoseiidae of northwest Iran (Acari: Mesostigmata). *Turkish Journal of Zoology*, 34(4), 497–508.  
<https://doi.org/10.3906/zoo-0902-23>
- Téllez, M.D.M., Cabello, T., Gámez, M., Burguillo, F.J. & Rodríguez, E. (2020) Comparative study of two predatory mites *Amblyseius swirskii* Athias-Henriot and *Transeius montdorensis* (Schicha) by predator-prey models for improving biological control of greenhouse cucumber. *Ecological Model*, 431: 109197. <https://doi.org/10.1016/j.ecolmodel.2020.109197>
- Tzortzakis, N.G. & Economakis, C. (2007) Antifungal activity of lemongrass (*Cymbopogon citratus* L.) essential oil against key postharvest pathogens. *Innovative Food Science & Emerging Technologies*, 8(2): 25–258. <https://doi.org/10.1016/j.ifset.2007.01.002>
- van Lenteren, J.V. (2003) Need for quality control of mass-produced biological control agents. In: van Lenteren, J.C. (Ed.), *Quality control and production of biological control agents: theory and testing procedures*. CABI Publishing, Wallingford, UK, pp. 1–18.
- van Lenteren, J., Nicoli, G., Heinz, K. & Parell, M. (2004) Quality control of mass-produced beneficial insects. In: Heinz, K.M., Van Driesche, R.G. & Parrella, M.P. (Eds.), *Biocontrol in Protected Culture*. Ball Publishing: Batavia, IL, USA, 2004; pp. 239–251.
- Yari, S., Farazmand, A., Zemek, R. & Arbabi, M. (2024) A practical mass-rearing system for phytoseiid mites: A case study with *Amblyseius swirskii*, *Neoseiulus californicus*, and *Neoseiulus barkeri*. *Persian Journal*

*of Acarology*, 14(2): 295–304. <https://doi.org/10.22073/pja.v14i2.86465>

Yeşilayer, A. (2021) Biological control agents of mites. *Modern Concepts and Developments in Agronomy*, 8(2): 803–804. <https://doi.org/10.31031/MCDA.2021.08.000685>

# ارزیابی برخی از عوامل افزودنی در سرکوب رشد کپک در محیط پرورش هرناهای فیتوزئید:

## تأثیر بر *Amblyseius swirskii* و *Transeius wainsteini* (Acari: Phytoseiidae)

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#### چکیده

پرورش موفق شکارگران و پارازیتوئیدها نقش حیاتی در اثربخشی برنامه‌های مهار زیستی ایفا می‌کند. یکی از چالش‌های کلیدی در پرورش هرناهای فیتوزئید، به ویژه *Amblyseius swirskii* و *Transeius wainsteini*، مدیریت رشد کپک در رژیم غذایی آنهاست. این مطالعه اثربخشی سه پودر گیاهی، آویشن، چای سبز و علف لیمو، و همچنین یک ماده شیمیایی، پروپیونات کلسیم، را در سرکوب رشد کپک ارزیابی می‌کند. آزمایش‌ها با استفاده از یک رژیم غذایی متشکل از گرده لویی و پوسته برنج تحت شرایط آزمایشگاهی (دمای  $25 \pm 1$  درجه سلسیوس، رطوبت نسبی  $65 \pm 5$  درصد و دوره نوری ۱۶:۸ ساعت) انجام شد. رژیم غذایی فاقد افزودنی به عنوان شاهد در نظر گرفته شد. برای ارزیابی رشد کپک در هر واحد پرورش، از شاخص عددی آلودگی کپک (MCI)، که از ۰ تا ۴ متغیر بود، استفاده شد. نتایج نشان داد که پروپیونات کلسیم تنها عاملی است که می‌تواند رشد کپک را در محیط‌های پرورش هر دو گونه هرنا با MCI برابر با صفر به‌طور مؤثری مهار کند، در حالی که تیمار شاهد دارای مقادیر MCI برابر با  $1/45$  برای *A. swirskii* و  $1/40$  برای *T. wainsteini* بود. افزودن پروپیونات کلسیم به رژیم غذایی، میزان رشد جمعیت هرناهای فیتوزئید را به مقدار زیادی افزایش داد. در مقایسه با تیمارهای شاهد که به ترتیب فقط  $2/3\%$  و  $1/74\%$  افزایش جمعیت در طول یک ماه نشان دادند، این مقدار برای *A. swirskii* به  $31/95\%$  و برای *T. wainsteini* به  $23/57\%$  رسید. در مقابل، افزودن پودرهای گیاهی مانع رشد کپک نشد و نسبت به گروه شاهد، نرخ رشد جمعیت کاهش یافت. مخلوط گرده لویی، پوسته برنج و پروپیونات کلسیم مواد مغذی کافی را برای هر دو گونه هرنا فراهم و رشد سالم و تکثیر سریع آنها را آسان کرد. در نتیجه جمعیت *A. swirskii* و *T. wainsteini* در طول یک ماه به ترتیب به  $494/3$  و  $368/6$  (مجموع همه مراحل رشدی) رسید (جمعیت نخستین برابر ۱۵ هرنا کامل بود). این مطالعه راهبرد امیدوارکننده‌ای را برای مدیریت کپک در رژیم‌های غذایی هرناهای فیتوزئید ارائه می‌دهد و در نهایت شرایط پرورش سالم‌تری را برای آنها فراهم می‌سازد.

**واژگان کلیدی:** کلسیم پروپیونات، پودر گیاهی، پرورش انبوه، رشد کپک، هرناهای فیتوزئید

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