The use of chitosan in the composition of feed "BeeHit" for honey bees

Marina Frolova¹, Alexey Albulov¹, Elana Kovaleva¹, Anatoly Eliseev¹, Andrey Gryn¹, Valery Varlamov¹,², Irina Matveeva¹, Vladimir Eremets¹, and Yuri Frolov¹

¹All-Russian Scientific Research and Technological Institute of Biological Industry, 141142 Moscow region, Russia
²Federal Research Centre «Fundamentals of Biotechnology» of the Russian Academy of Sciences, Leninsky prospekt 33, 119071 Moscow, Russia

Abstract. Nowadays, chitosan-based biostimulants and their derivatives are being increasingly utilized in veterinary medicine. These substances possess numerous advantageous properties that make them suitable for application in beekeeping. Chitosan and its modified forms are of natural origin and non-toxic, exhibiting immunomodulating properties and antimicrobial activity. They also have the ability to enhance resistance and eliminate heavy metals and toxins from bees' bodies. Chitosan is derived from chitin, a natural component found in the exoskeleton of bees. When acted upon by enzymes like chitinase and chitobiase, chitin and chitosan break down into N-acetyl-D-glucosamine. This characteristic renders chitosan completely biodegradable, ensuring it does not contribute to environmental pollution as it degrades into carbon dioxide (CO2) and water (H2O). Moreover, chitosan boosts bees' resilience against adverse environmental factors and various pathogens. Being naturally biocompatible and biodegradable, chitosan and its derivatives exhibit significant antibacterial, sorbent, fungicidal, and antiviral properties. The aim of the study was to analyze the impact of incorporating chitosan into the composition of "BeeHit" bee feed.

1 Introduction

Bees have a significant role in our daily lives. They not only produce valuable products like honey, but they also play a crucial role in pollinating a large portion of flowering plants, which make up around 80-95% of cultivated plants. However, there is growing concern among scientists and beekeepers about the alarming decline in bee populations, known as colony collapse disorder. This decline is attributed to various factors such as the use of pesticides, herbicides, and acaricides, as well as the presence of diseases and electromagnetic radiation.

Scientists have discovered that chitosan, a natural polysaccharide, possesses adaptogenic properties and can help bees withstand environmental stressors. Chitosan, due to its positive charge, acts as a highly active anionite, capable of binding and removing heavy metals,
radioactive isotopes, and toxic elements from animals' bodies, including bees. It has been found that chitosan-based medicines have antiviral, antibacterial, antidote, anticoagulant, antioxidant, immunocorrecting, and immuno-adjuvant properties. This makes it a promising candidate for developing chitosan-based drugs to combat colony collapse disorder.

An important stage in the life of bee colonies is successful wintering, as it greatly influences their productivity and development. Unfortunately, during wintering, around 20-30% of bee colonies are lost annually, and by spring, the surviving bees are noticeably weakened. To ensure a sufficient number of worker bees for honey production and crop pollination in the spring-summer period, it is crucial to stimulate egg laying by the queen bee. Bringing nectar and pollen to the hive stimulates the bees' activity and increases egg laying. Conversely, when honey harvesting decreases or stops, egg laying decreases, resulting in slower colony growth.

Currently, researchers are continuously searching for solutions to address these challenges and ensure the survival and well-being of bee populations.

2 Materials and Methods

A study was conducted in private bee farms in the Moscow region and the Crimea Republic to investigate the impact of chitosan in the composition of "BeeHit" feed on the economic benefits of bee families. The experiment involved control groups of bees that were given 60% sugar syrup, while the study groups received 60% sugar syrup with the addition of 4g of chitosan-containing feed per liter of sugar syrup. This feeding regime was administered once a week for a month. The power of the bee families (measured by the number of seams) and the egg production of the queen bees (brood) were analyzed before and after the 30-day test period.

Another investigation was carried out at FGUP PPH Maikopskaya in the North Caucasus region, from August 15, 2018, to April 1, 2019, to examine the effects of the multifunctional "BeeHit" feed on the power of bee families, brood production, and wintering of bees. Two groups of bees (control and study) were formed, each consisting of three bee families. The control group was given 60% sugar syrup, while the study group received 60% sugar syrup with the addition of 4g of "BeeHit" feed per liter of sugar syrup. This feeding regimen was administered once a week for a month, from August 15, 2018, to September 15, 2018. From September 15 to October 1, 2018, the bee families in the study group received daily feed to replenish their winter food supplies.

3 Results and Discussion

Results of the test of the "BeeHit" feed for honey bees for assessment of the economically beneficial signs in bee families in private bee farms (Moscow region) are presented in table 1.

Table 1. Effect of "BeeHit" multifunctional feed on economically beneficial signs of bee families in the conditions of private bee farms (Moscow region)

<table>
<thead>
<tr>
<th>Group</th>
<th>Strength of families (number of seams)</th>
<th>Brood (number of cells)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test start (May 28, 2018)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=3)</td>
<td>4.5</td>
<td>17,771</td>
</tr>
<tr>
<td>Study (n=3)</td>
<td>5.0</td>
<td>14,607</td>
</tr>
</tbody>
</table>
Data in table 1 show that the strength of bee families and brood in control group increased by 71.1% and 50.8 per cent over the observation period vs. baseline, in the study group increase was 106.0% and 125.1%, respectively.

Results of the test of the "BeeHit" feed for honey bees for assessment of the economically beneficial signs in bee families in private bee farms (Crimea Republic) are presented in table 2.

Table 2. Effect of "BeeHit" multifunctional feed on economically beneficial signs of bee families in the conditions of private bee farms (Crimea Republic)

<table>
<thead>
<tr>
<th>Group</th>
<th>Strength of families (number of seams)</th>
<th>Brood (number of cells)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test start (March 18, 2019)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=13)</td>
<td>2.9</td>
<td>2,820</td>
</tr>
<tr>
<td>Study (n=13)</td>
<td>2.9</td>
<td>2,641</td>
</tr>
<tr>
<td>Test midpoint (March 28, 2019)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=13)</td>
<td>3.0</td>
<td>63,39</td>
</tr>
<tr>
<td>Study (n=13)</td>
<td>3.2</td>
<td>7,112</td>
</tr>
<tr>
<td>Test end (April 18, 2019)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (n=13)</td>
<td>6.5</td>
<td>16,723</td>
</tr>
<tr>
<td>Study (n=13)</td>
<td>7.1</td>
<td>18,199</td>
</tr>
</tbody>
</table>

According to the data presented in Table 2, the strength of bee families and brood in the control group increased by 3.4% and 124.8% respectively, compared to the initial baseline, at the midpoint of the test. In contrast, the study group showed an increase of 10.3% and 169.3% respectively. By the end of the test, the control group exhibited an increase of 24.1% and 493.0% in family strength and brood, while the study group showed a higher increase of 44.8% and 589.1% respectively.

The loss of bee families is a significant concern in modern beekeeping. To ensure an adequate number of working bees during the mass honey gathering period, it is crucial to stimulate the egg-laying process by the queen bee. The results of a study conducted on the impact of "BeeHit" multifunctional feed on economically important indicators of bee families in FGUP PPH Maikopskaya, located in the North Caucasus region, are presented in Tables 3 and 4.

Table 3. Effect of "BeeHit" multifunctional feed on economical parameters of bee families in FGUP PPH “Maikopskaya” (North Caucasus region)

<table>
<thead>
<tr>
<th>Bee colonies group</th>
<th>Power of families (number of seams)</th>
<th>Brood (number of cells)</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 15, 2018</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
According to the data presented in table 3, one month after the start of the test, the control group experienced a decrease of 20.6% and 29.4% in bee families and brood area respectively, compared to the initial measurements. The study group, on the other hand, saw a decrease of 14.3% and 4.8% in the same parameters. By October 1, the control group showed a further decline of 52.4% in bee families and 63.1% in brood area compared to the initial measurements. The study group also experienced a decrease, but to a lesser extent, with 47.1% fewer bee families and a 39.5% reduction in brood area. These findings suggest that the bee families were entering the preparation phase for wintering.

Table 4. Effect of "BeeHit" multifunctional feed on wintering of bee families in FGUP PPH “Maikopskaya” (North Caucasus region)

<table>
<thead>
<tr>
<th>Group</th>
<th>Frame number</th>
<th>Strength of families (number of seams)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Autumn revision of bee families (October 1, 2018)</td>
<td></td>
</tr>
<tr>
<td>Control (n=3)</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Study (n=3)</td>
<td>4.7</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Spring revision of bee families (April 1, 2019)</td>
<td></td>
</tr>
<tr>
<td>Control (n=3)</td>
<td>3.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Study (n=3)</td>
<td>4.0</td>
<td>3.3</td>
</tr>
</tbody>
</table>

According to the data presented in table 4, the control group experienced a reduction of 17.5% in the number of frames and 23.3% in the number of seams on the day of the spring revision. Similarly, the study group observed a decrease of 14.9% in frames and 10.8% in seams. This indicates that the utilization of BeeHit feed, in conjunction with sugar syrup, during the summer-autumn period and prior to wintering, had a beneficial impact on the vitality of bee colonies, the brood population, and their survival throughout the winter season.

This study suggests that the application of BeeHit feed, along with sugar syrup, can contribute to the overall strength and health of bee families, leading to improved brood development and enhanced survival rates during the wintering phase.

4 Conclusion

Provision of "BeeHit" multifunctional feed for honey bees had a positive effect on economical parameters of bee families and safety during the wintering period. The obtained results complement the scientific justification for the use of chitosan as an effective adaptogen with multifunctional properties, providing resistance to numerous unfavorable environmental factors.
The authors declare that they have no funding support for this study. The authors declare that there is no known conflict of interest associated with this publication.

References


