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PP-403 [Bee Biology]

Feed supplementation with a molybdenum complex improves honey bee health

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Introduction

Nutrition is key to improving the health of colonies [1]. Several products based on vitamins, peptides, proteins or probiotics have been developed for beekeepers. However, despite their essential role in numerous physiological processes for animal health, metals have been surprisingly understudied.

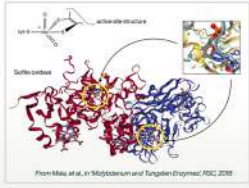
Among crucial trace elements, molybdenum (Mo) is often neglected and its role on honey bee health is almost unknown to date. In this presentation, we investigated the potential benefits of a molybdenum-based dietary supplement.

What is molybdenum?

Molybdenum is an essential trace element involved in more than **50 enzymes** [2].

For humans, Mo is involved in detoxification of body and growing of bones and teeth.
The daily requirement is 50-100 µg/day, primarily found in vegetables and organ meats.

Mo is naturally present in honey bees, at an average concentration of 0.4 ppm [3]. Its role remains poorly understood to date.



From Maia, et al., in 'Molybdenum and Tungsten Enzymes', RSC, 2016

What is Pep'up?

Pep'up, developed by Oligofeed, is the result of **10 years of interdisciplinary and international academic research.**

- A patented molybdenum-based molecule considered as a biomimetic model of enzymes [4]
- Highly stable, non-toxic and easy to handle: soluble in both syrup and fondant [3-6].
- Antioxidant in honey bees [3]
- Can increase the honey production without any impact on honey quality [3,5]

Assimilation of Mo by bees

Monitoring molybdenum levels in food storage confirms **Pep'up consumption over several weeks** [3].

Mo level analysis in larvae and worker bees demonstrates **assimilation of the Mo complex by both groups** within hives after feeding with Pep'up in sugar syrup (at D0) [3].

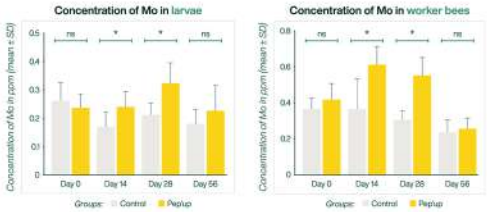


*Figure 1. Molybdenum concentration in larvae (left) and worker bees (right) over time, after Pep'up supplementation. Control group compared to Pep'up supplemented group at days 0, 14, 28, and 56. Statistical significance indicated by * (p < 0.05) and ns (non-significant).*

Laboratory feeding trials with Pep'up (400 mg/L) combined with X-ray fluorescence studies conducted at synchrotron SOLEIL, France (collaboration with Dr J.C. Sandoz, CNRS, France) evidenced:

- Mo naturally occurs in hypopharyngeal glands (HPGs).
- Pep'up supplementation caused a 14-fold increase in HPG molybdenum content.

These findings suggest that **HPGs appear as a primary target of Pep'up in honey bees.**

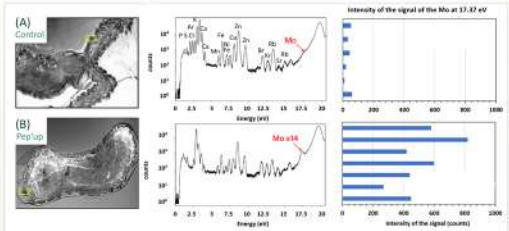


Figure 2. HPGs extracted from workers of the control group (A) and bees fed with Pep'up (B) with their corresponding total X-ray fluorescence spectra. The peak energy corresponding to Mo is indicated in red. 6 HPGs from the control group and 7 HPGs from the group fed with Pep'up were analyzed [3]. Mo is naturally present in HPGs. The intensity of the Mo signal increased 14 times in average after feeding with Pep'up.

Winter mortality reduction

To evaluate the effectiveness of Pep'up in reducing winter mortality, we conducted a large scale field trial across 6 apiaries in France and Spain (2023-2024), involving 247 hives from professional beekeepers.

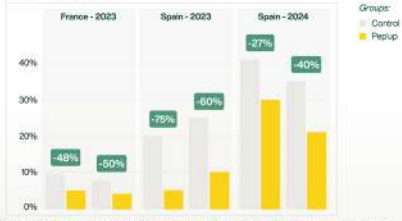


Figure 3. Winter mortality reduction in 2023-2024 in 6 apiaries in Spain and France. Control group compared to Pep'up supplemented group.

Results demonstrate **44% average winter mortality reduction across all apiaries**, with individual reductions **ranging from 27% to 75%** (GLMM, p = 0.029).

Demonstrated efficacy across Europe

Building on **10 years of academic and applied research**, Pep'up has demonstrated consistent efficacy through large-scale field studies conducted in **5 European countries**.

These studies involved **over 1,500 hives** in partnership with independent laboratories and professional beekeepers.

Perspectives

- Conduct new field tests in other environments to consolidate our results.
- Highlight environmental deficiencies in trace elements in Europe and elsewhere.
- Understand how our molecule works in bees: impact on HPGs, impact on royal jelly, impact on bee vitality, impact on the gut microbiota, etc.
- Obtain marketing authorizations in Europe, Canada, and the United States (in progress).

SATT PARIS-SACLAY · cnrs · UVSQ université PARIS-SACLAY · CHARMMAT · IUF institut universitaire de France · oligofeed

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Food supplementation with a molybdenum complex improves honeybee health

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While the honeybee Apis mellifera plays a major role in insect-mediated pollination, colony losses have systematically increased in the last decades through a multifactorial process. Honeybees obtain their nutrients from pollen gathered on flower resources and/or from turbid waters. In some cases, the lack of flower diversity can lead to nutritional deficiency, which is considered one of the main causes for colony mortality. One way to improve honeybees' health and resilience to stress is therefore to optimize their nutrition. To overcome nutritional stress, beekeepers can choose from different food supplements, such as sugar syrups and fondants. Micronutrients, and especially metals, are important for animals' health as they play an essential role in numerous physiological processes. However, little is known about the effect of micronutrients supplementation in field conditions and more generally about the metals that are needed for honeybees' health. Molybdenum (Mo) is a trace element of essential importance for life in almost all living organisms, which is naturally present in honeybees, but to date, its role in honeybees remains unknown. During the last decade, we developed a non-toxic molecule based on molybdenum and explored its efficiency as a food supplement for honeybees. This molecule diluted in syrup was recently tested through test campaigns led on 173 hives spread within four apiaries in France and Spain. The effect of supplementation on overwintering mortality, and honey production were evaluated. We observed a decrease of overwinter mortality for the 4 apiaries and an increase of honey production. These results will be presented in the context of the nutritional status (protein, lipids and carbohydrate) of worker honeybees, and the activity of the enzyme alkaline phosphatase.