

RESEARCH TEAM

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NEW ZEALAND

Use of Alternative Protein Sources in the Nutrition of Honey Bees

Under Commercial Colony Management Conditions in New Zealand

Modern beekeeping and climate change place honey bees under constant stress, depleting their immune resources and reducing their recovery ability. Complete nutrition, beyond basic proteins, fats, and carbohydrates, must include amino acids, polyunsaturated fatty acids, enzymes, microelements, and phytonutrients. This approach supports colony health, productivity, and physiological resilience, particularly under intensive commercial use.

Our research investigated spirulina as a promising protein alternative under commercial queen-rearing conditions. Spirulina is notable for its high protein content, balanced amino acid profile, polyunsaturated fatty acids (linolenic acid), and antioxidants, aligning well with the biological needs of honey bees. Unlike many commercial protein substitutes with limited amino acid content and digestibility, spirulina provides comprehensive nutrition (see figure 1).

Figure 1. Stepwise optimisation of spirulina-based formulations

Experimental diets were initially screened in colonies to assess physical characteristics and acceptance compared to commercial protein feed (control). Based on field observations, formulations were adjusted for texture and intake. Final-stage testing confirmed consistent consumption and integration into colony feeding behaviour.



METHODS

The study emphasized spirulina's effect on hypopharyngeal gland development, royal jelly production, and colony resilience during intensive queen-rearing cycles. At a concentration of 30% of the total feed, spirulina effectively met protein and amino acid requirements while enhancing hypopharyngeal gland functionality, critical for larval nutrition and queen quality. Physiologically healthy larvae for grafting were consistently available, boosting queen production efficiency (see figure 2).

Figure 2. Multi-choice feeding preference test for protein supplements

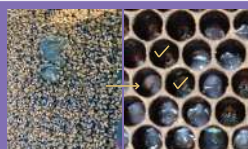


RESULTS

Although spirulina alone demonstrated positive effects, its benefits were maximized when combined with key minerals such as magnesium, zinc, and manganese. Under laboratory conditions, this enhanced diet supported physiological resilience, as evidenced by a 30% survival rate in the spirulina-fed group compared to 28% in the commercial feed group. While the numerical difference is modest and not necessarily statistically significant, it confirms the non-toxicity and nutritional adequacy of the spirulina-based diet for sustaining longevity. Notably, royal jelly deposition in queen cells increased by approximately 12%. Nurse bees receiving this diet began filling queen cups with royal jelly as early as the egg stage - prior to larval hatching - which is rarely observed in practice and suggests an overcapacity of jelly production, likely indicating enhanced hypopharyngeal gland activity and improved physiological status under stress (see figure 3).

Figure 3. Spirulina's complex nutrient profile

Rich in protein, amino acids, and bioavailable trace elements such as magnesium, zinc, and manganese — provides a biologically relevant supplement for supporting physiological functions in honey bee colonies under intensive commercial use.



CONCLUSION

These findings highlight spirulina's potential as a superior protein source for bees, particularly in commercial operations. By improving colony nutrition, spirulina enhances productivity, supports hypopharyngeal gland health, and increases stress resilience. Combining spirulina with essential minerals ensures optimal results, offering an effective solution to address nutritional deficits and sustain bee health under modern intensive beekeeping conditions (see figure 4).

Spirulina represents a viable alternative to commercial pollen substitutes, capable of significantly improving colony performance, resilience, and the production of high-quality queens.

Figure 4. Invertase Testing

As part of our preliminary efforts to validate the proposed hypothesis, we performed ¹³C NMR profiling of bee head extracts. The resulting spectra indicated distinguishable features potentially linked to invertase activity. While further confirmation is needed, early patterns suggest increased enzymatic signals in forager bees from colonies receiving spirulina-based protein supplementation. These findings align with the observed positive effects on hypopharyngeal gland development.



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Modern beekeeping and climate change place honey bees under constant stress, depleting their immune resources and reducing their recovery ability. Complete nutrition, beyond basic proteins, fats, and carbohydrates, must include amino acids, polyunsaturated fatty acids, enzymes, microelements, and phytonutrients. This approach supports colony health, productivity, and physiological resilience, particularly under intensive commercial use. Our research investigated spirulina as a promising protein alternative under commercial queen-rearing conditions. Spirulina is notable for its high protein content, balanced amino acid profile, polyunsaturated fatty acids (linolenic acid), and antioxidants, aligning well with the biological needs of honey bees. Unlike many commercial protein substitutes with limited amino acid content and digestibility, spirulina provides comprehensive nutrition. The study emphasized spirulina's effect on hypopharyngeal gland development, royal jelly production, and colony resilience during intensive queen-rearing cycles. At a concentration of 30% of the total feed, spirulina effectively met protein and amino acid requirements while enhancing hypopharyngeal gland functionality, critical for larval nutrition and queen quality. Physiologically healthy larvae for grafting were consistently available, boosting queen production efficiency. Although spirulina alone showed positive results, its maximum benefit emerged when combined with minerals such as magnesium, zinc, and manganese. This enhanced diet extended the bees' lifespan under laboratory conditions, with 30% survival for the spirulina-fed group compared to 28% for the commercial feed group. Notably, royal jelly production increased by 12% in queen cells. Nurse bees fed this diet began filling queen cells with royal jelly as early as the three-day egg stage, indicating a surplus of royal jelly—a key marker of physiological health under stress. These findings highlight spirulina's potential as a superior protein source for bees, particularly in commercial operations. By improving colony nutrition, spirulina enhances productivity, supports hypopharyngeal gland health, and increases stress resilience. Combining spirulina with essential minerals ensures optimal results, offering an effective solution to address nutritional deficits and sustain bee health under modern intensive beekeeping conditions. Spirulina represents a viable alternative to commercial pollen substitutes, capable of significantly improving colony performance, resilience, and the production of high-quality queens.