WOULD ADDING SPIRULINA TO A COMMERCIAL POLLEN SUPPLEMENT IMPROVE COLONY HEALTH

Yes, adding Spirulina to a commercial pollen supplement is likely to improve honey bee colony health. Spirulina is a blue-green microalgae with a strong nutritional profile that closely mimics natural pollen, offering several benefits that commercial substitutes often lack.

Nutritional benefits of Spirulina

Spirulina provides a powerful boost of essential macronutrients and micronutrients that are vital for honeybees.

- **Complete protein source:** It is rich in essential amino acids, matching or exceeding the levels found in natural pollen samples. Studies have shown that bees fed a Spirulina diet develop heavier thoraxes and comparable head protein content to bees on a natural pollen diet.

- Footnote 1. Common pollen substitute is more or less an old guess on the makeup of natural pollen. The bulk powder is probably soybean flour to achieve a high protein content. Does pollen substitute do more than just keep the honeybees alive?

- **Source of lipids:** Spirulina is a source of lipids and polyunsaturated fatty acids, which are critical for bee development, energy storage, and immune function.

- Footnote 2. My idea of a "fat and healthy" bee is hard to see. Limpid fat is essential to the bee storing body fat in the internal "fat bodies" in the abdomen. This is the body fat storage area of the honeybee. The varroa mite attacks this "gland" drilling a hole through the potential abdomen of the larvae. The mite then injects a solvent with the viruses to melt the fat and suck the fat out as mite food.

- **Prebiotic properties:** The microalgae support the growth of beneficial gut bacteria, which can enhance bee health and improve digestive function.

- **Antioxidants and vitamins:** It is a rich source of antioxidants, including beta-carotene, which can help bees counteract the negative effects of environmental stressors like pesticides. Spirulina also contains B-vitamins, which are especially important for brood rearing.

The USDA Agricultural Research Service (ARS) has conducted significant research demonstrating that **microalgae can serve as a highly nutritious and sustainable artificial diet or supplement for honeybees**.

Key Findings of USDA ARS Research:

- **Nutritional Value:** Microalgae, specifically *Chlorella vulgaris* and *Arthrospira platensis* (spirulina), have a nutrient profile similar to natural pollen, containing essential macronutrients (proteins, lipids, prebiotic fibers), micronutrients, and antioxidants.

- **Improved Bee Health:** Bees fed diets containing microalgae showed several health benefits compared to those on other artificial diets:

    - **Increased Longevity:** Bees on microalgae diets lived significantly longer than those on a base diet without it. Bees fed the pollen-containing diet lived the longest (median lifespan = 51 days), bees fed spirulina- and Chlorella-containing diets lived significantly longer (median lifespan = 48 and 46 days, respectively) than those fed the base diet (median lifespan = 40 days).

- Footnote 3. Forever, it was said the honeybee lived 4-6 weeks after she started foraging. They start foraging at about 14 days old. Our current bees are probably infected with viruses as larvae. Do they work for 6 weeks or more likely 4. They are also sick, so they are not as industrious as old-time non-infected honeybees. So, the best we can expect is a total life span of 49 days. Hence, the microalgae diet did not add much longer life statistically than honeybees on a natural diet (2 days longer). Spirulina diet fed bees lived plus or minus 45 days. No statistical difference. Bees fed the not described "base diet" lived 40 days. Still no statistical difference. I conclude that this product did not increase the life span of the average honeybee.
- WHAT DID IT DO FOR THE INCREASED FEEDING COST?
- It might have improved the health of the bee by moving the bell curve to the right causing some of the bees to live longer but more importantly improving the bee's health, allowing it to be more industrious over its working life. That is important!

    - **Better Immunity:** Microalgae enhanced the expression of immune-related genes and the bees' ability to fight off bacterial infections. Spirulina-fed bees exhibited significantly higher expression of several antimicrobial peptide (AMP) genes relative to the base diet and had superior bacterial clearing ability after injection with live E. coli cells

- Footnote 4. Most honeybees are not "fighting off" bacterial infection (which is great) but are battling the numerous viruses vectored by the varroa mite. A stronger bee might be able to carry a larger viral load than a non-enhanced individual bee. Humans carry MRSA, staph, and strep all the time. The diseases do not manifest in the body until extra ordinary stress is applied (illness or surgery). We also breath botulism bacteria all the time, spread by decaying road kill or dead rats in the attic. We need to get an overdose to adversely affect us.

    - **Larger Size and Vigor:** Bees grew to larger sizes and were generally more vigorous.

- Footnote 5. Larger size of treated honeybees may be the key factor here. The varroa mite with all its viruses cohabitates with the Asian bee which is larger than our Apis mellifera honeybee. The larger Asian bee evolved with the mite et al. A. mellifera did not. Another advantage may be the larger thorax found in the diet enhanced honeybee which allows for internal organs to grow larger. The expanded honey stomach can carry more nectar back to the colony. The extra thorax space can allow the straight through simple gut track to grow longer, aiding in digestion. The fat bodies where internal body fat is stored can expand holding more fat to bridge dearth periods. I base the larger organ theory on the fact that honeybee larvae size and gestation time increase when grown in larger comb cells. Small cells produce smaller bees a few days faster than large cells (drone cells and regular cells).

    - **Healthy Gut Bacteria:** The prebiotic qualities of algae promote healthier gut bacteria in the bees.

- **Disease Resistance:** Engineered strains of blue-green algae have been developed that, when added to feed, can boost the bee's immune system to fight off specific pathogens, such as the Deformed Wing Virus (DWV).

Footnote 6. I think Deformed wing virus, K wing virus, and hairless Black bee virus are the only viruses that can be seen externally on the honeybee with the naked eye.

- **Sustainable and Scalable:** Microalgae can be mass-produced sustainably in shallow ponds using minimal water and simple nutrient inputs, making it an ecologically friendly and scalable alternative to traditional pollen substitutes, which often rely on crops like soy or corn.

- **Commercial Potential:** The technology can be directly added to supplemental feed without additional processing, making it easy for beekeepers to integrate into existing management practices. Researchers have filed a patent application for this technology.

Positive impact on bee health and colony performance

Research indicates that including Spirulina in bee diets can have several positive effects on the colony as a whole.

- **Increased brood production:** Studies have found that colonies fed with Spirulina-enhanced diets experience a significant increase in total brood area.
- **Larger colony populations:** This boost in brood production can lead to larger, more robust colony populations.
- **Improved stress resilience:** The enhanced nutrition provided by Spirulina, along with its antioxidant properties, can make colonies more resilient to various environmental and biological stressors.

Besides providing essential nutrition, microalgae offer several other significant benefits to honeybees, as identified by USDA ARS and other research:

- **Enhanced Immune Response:** The bioactive compounds, antioxidants, and specific components within microalgae stimulate the honeybee's immune system, making them better equipped to fight off infections.
- **Improved Gut Health (Prebiotic Effects):** The fiber components in microalgae act as prebiotics, promoting a healthy balance of beneficial gut bacteria in the bees. A healthy gut microbiome is crucial for digestion, immunity, and overall well-being.

  See Footnote 5 Above
- **Disease Resistance:**
  - Bees fed microalgae-enhanced diets show improved resistance to common bacterial infections.
  - Specific genetic engineering of certain algae strains by ARS researchers allows for the delivery of an "immune boost" that helps bees target and fight specific viruses, such as the Deformed Wing Virus (DWV).
- **Stress and Toxin Tolerance:** The high levels of antioxidants in microalgae help mitigate oxidative stress caused by environmental factors like pesticide exposure and other toxins.
- **Increased Longevity and Vigor:** Bees on microalgae diets live significantly longer and display greater vitality compared to those on base diets or poorer-quality pollen substitutes.
- **Sustainable and Consistent Source:** Unlike natural pollen, which can be scarce or vary greatly in quality due to agriculture, climate, and geography, mass-produced microalgae provide a consistent, high-quality, and reliable food source, addressing widespread malnutrition.
- Footnote 8. All pollen is not of the same nutritional quality. However, what is the guarantee that all mass-produced microalgae from different companies and different growth sources will be equal to the specific needs of the honeybee.
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Factors to consider

While Spirulina offers significant advantages, a few factors should be considered when adding it to a pollen substitute.

- **Bee consumption:** Some studies have noted that bees consume less of a pure Spirulina diet compared to natural pollen, but they still assimilate the nutrients effectively and show positive health indicators.
- **Additives and attractiveness:** To improve palatability and consumption, Spirulina is best used as a supplement to an existing pollen patty rather than as a complete substitute. Some commercial products combine it with other ingredients to make it more attractive to bees.
- **Method of delivery:** Beekeepers should follow recommended mixing and feeding instructions to ensure the bees consume the supplement effectively. For example, dry powder mixed with sugar syrup may be more palatable and prevent clumping.

Chlorella vulgaris and *Arthrospira platensis* (**Spirulina**) used in USDA ARS studies) are comparable to natural pollen, though the specific percentages can vary slightly depending on the source of the pollen and the growing conditions of the algae.

Here is a general comparison of the key macronutrients based on USDA ARS research:

Nutrient	Microalgae (dry weight %)	Natural Pollen (average dry weight %)
Protein	~45-60%	~20-35%
Lipids (Fats)	~5-15%	~3-10%
Carbohydrates	~10-25%	~40-60%
Ash (Minerals)	~5-10%	~2-5%
Moisture	~3-8% (in powder form)	~4-10% (in powder form)

Key Differences and Similarities:

- **Protein Content:** Microalgae typically have a **higher protein concentration** than most natural pollens [2]. This higher protein level is a major advantage, making it a highly effective protein supplement for bee development and immunity [2, 3].
- **Amino Acid Profile:** Both microalgae and pollen provide the ten essential amino acids required by honeybees for growth and development [2, 3]. Research has confirmed that the amino acid profile of microalgae is highly suitable for honeybee nutrition [3].
- Footnote 9. Bad statement! Both microalgae and pollen provide the 10 essential amino acids required…. Or do they mean each provides the 10, or sometimes pollen does not have the 10 but combined you are guaranteeing the honeybee gets the 10? Does the bee need all 10 amino acids all the time or does the requirement change as the activities in the hive change (brood rearing, honey processing, winter cluster sustainment)? Do the microalgae have the same shelf life after being mixed into the bee bread as bee bread without the algae? Unfortified bee bread can last, without molding, from October to March, here in the north Georgia mountains in a live colony. This treatment could substitute for adding ammino acid supplement (Honey B Healthy vitamins, amino acids, minerals).
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- **Lipid Profile:** While lipid content is similar, the **fatty acid profile** is crucial. Microalgae provide essential fatty acids necessary for bee health and often found in high-quality pollens [2].

- Footnote 10. The stored lipid fat is necessary for winter survival. With the varroa mite sucking the stored fat out of the honeybee's fat bodies (those storage sacks in the abdomen) the need for enhanced supplemental feeding becomes critical for long winter survival. We frequently see the honeybee showing signs of starving to death by the end of January or February with stored honey just inches away. Indicating the bees did not die from lack of carbohydrate but may be the lack of "stored fat". Either stored in the honeybee body or as bee bread.

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- **Carbohydrate Content:** Pollen generally has a higher proportion of carbohydrates, which provide a primary energy source [2]. Microalgae still contain carbohydrates, including prebiotic fibers that benefit gut health, but less than pollen [3].

- Footnote 11. Harvested pollen generally has a higher carbohydrate content than what (stored honey and/or bee bread)? Nectar or Honey is the honeybees' main source of carbohydrates, pollen may contain some carbohydrates, and bee bread may have some also? Bee bread (the yellow stuff in the cell we typically call pollen) is a processed mixture of pollen, enzymes, and honey. It is shelf stable for a while. When fed to larvae the nurse bee usually mixes in a little more water diluted honey. Pollen is a protein and fat source for the honeybee

- **Micronutrients:** Both sources are rich in micronutrients, including vitamins, minerals, and antioxidants, which contribute to improved immune function and overall colony vitality [2, 3].

Microalgae, particularly species like *Arthrospira platensis* (spirulina) and *Chlorella vulgaris*, have a robust nutritional profile that closely mirrors natural pollen, making them excellent substitutes in honeybee diets.

The table below provides a general comparison of the main macronutrients as a percentage of dry weight.

Nutrient Category	Natural Pollen (Approximate Range)	Microalgae (Approximate Range, e.g., Spirulina, Chlorella)
Protein	10–60% (Avg. ~23%)	40–70% (e.g., *Chlorella* up to 58%)
Lipids (Fats)	2–20%	10–50% (Species dependent)
Carbohydrates	1–40%	12–30%

Key Nutritional Similarities and Differences:

- **Protein and Amino Acids:** Microalgae are exceptionally rich in protein, often containing a higher percentage than the average pollen sample. They contain all the essential amino acids required by honeybees, with a balanced profile similar to high-quality protein sources like soy or eggs.

- **Lipids and Fatty Acids:** Pollen is highly variable in its lipid content depending on the plant source. Microalgae are renowned for their healthy lipid content, including essential polyunsaturated fatty acids (PUFAs) like linoleic and -linoleic acids, which are vital for bee health and fat body development.

- **See Footnote 10 above**

- **Micronutrients and Bioactive Compounds:** Both pollen and microalgae are rich sources of essential vitamins (A, C, D, E, K, B-vitamins) and minerals. Microalgae also contain beneficial phytochemicals and antioxidants, such as carotenoids, that can boost the bee's stress and immune responses.

- **Digestibility and Gut Health:** While some raw microalgae have rigid cell walls that may limit digestibility in humans, the species tested by the USDA ARS (spirulina and chlorella) are digestible by honeybees and act as prebiotics, supporting healthy gut bacteria, similar to natural pollen.

- **Variability:** The nutritional composition of natural pollen can be highly variable depending on floral source, location, and season. In contrast, the nutritional profile of commercially produced microalgae is more consistent and can be tailored during cultivation to ensure a complete and balanced diet for bees.

The optimal way to feed microalgae to honeybees is by

incorporating it as a **dry powder** into either a **pollen patty (solid feed)** or a **sugar syrup mixture (liquid feed)**, effectively replacing some or all the traditional protein sources like soy or other pollen substitutes.

Here are specific recommendations based on USDA ARS research and application methods:

1. As a Pollen Patty (Solid Feed)

This is the most common and practical method, especially during periods of brood rearing when bees actively seek solid protein sources.

- **Mixing Method:** The microalgae powder is thoroughly mixed with other standard ingredients such as sugar, water, and other binders (e.g., soy flour, specific oils) to form a dough-like patty.
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- **Concentration:** USDA ARS studies have shown success with diets where microalgae make up a significant portion of the protein component, often replacing traditional protein sources entirely or in part. A common effective concentration in a patty might involve 10-20% microalgae powder by weight of the final dry mixture.
- **Placement:** The patties are placed directly inside the hive, typically on top of the brood frames, where the bees can easily access and consume them.

2. As a Liquid Feed Supplement (Sugar Syrup)

This method is suitable for boosting overall colony health or delivering specific immune-enhancing algae strains, particularly during periods when bees are foraging for nectar but not protein.

- **Mixing Method:** The microalgae powder is mixed into a sugar syrup (typically a 1:1 or 2:1 sugar-to-water ratio by volume). Because the powder is fine, it can be suspended in the syrup.
- 12 & 16. The shortest pathway to get the enhanced diet to the larvae is using “pollen patties”. This makes sense because the nurse bees are moving the pollen patty to the brood area directly. Some science shows that very little pollen is fed to the larvae. The nurse bee eats the pollen patty stimulating her improved enzyme production which is then mixed with very little bee bread as larval food.
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- **Concentration:** Researchers have experimented with various concentrations; specific viral-mitigating strains were effective at concentrations that are easily consumed by bees.
- **Placement:** The fortified syrup is provided in standard hive feeders (e.g., entrance feeders, top feeders, or in-hive frame feeders).

Key Considerations:

- **Acceptance:** Bees readily accept microalgae-based diets because the color (green, similar to some natural pollens) and nutrient profile appeal to them.
- Footnote 13. Mixing the microalgae with syrup could be a way to enhance the adult honeybees’ immune system. The honey made from and stored in the comb for later food might enhance bees through dearth periods (including winter) and to larvae when that honey is mixed with larval food. Bees don’t particularly care what color their honey is. The story

goes that France had some bright blue honey. It was made from M&M candy coating that came out the wrong color so the factory just dumped it out back. The bees were licking up the melting candy as a sugar product. Bees eat hard candy sugar including candy canes with red and peppermint. They will also eat "red hots".

- Mix the powdered microalgae with a cool syrup mix so the hot syrup does not damage the microalgae. You may need liquid lecithin to mix with the algae powder before mixing with the thinner syrup to get everything into suspension and have it stay there. If it settles out in the feeder that is okay. Eventually the bees will eat that sludge in the bottom of the feeder or it will get re-suspended for a while when you refill the feeder.

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- **No Extra Processing:** The beauty of the ARS approach is that the *Chlorella* and *Arthrospira* powders can be used as-is, requiring no complex processing before mixing into the feed.

- **Customization:** Beekeepers can adjust the ratio of microalgae to other components to create a balanced diet tailored to specific colony needs, whether for general nutrition, immune support, or disease intervention.

According to USDA ARS research, the most effective and optimal ways to feed microalgae to honeybees are by incorporating it into **pollen substitute patties** (a paste consistency) or as a supplement mixed into **sugar syrup**. The key is to blend it into a form that bees readily consume within the hive.

1. In a Pollen Substitute Patty (Paste Form)

This is the primary method used in many USDA ARS studies and large-scale field trials.

Footnote 14. Most sideliner and hobbyist beekeepers do not make their own pollen patties.

- **Preparation:** The dried microalgae powder (such as *Chlorella vulgaris* or *Arthrospira platensis* / spirulina) is mixed with a liquid, typically 50% sucrose syrup or a mixture of honey and syrup, to achieve a dough-like or paste consistency, similar to a commercial pollen patty. Glycerol can be added to maintain moisture and pliability.

- **Ratio:** Researchers used a ratio of approximately **two parts dry ingredients (microalgae powder, possibly mixed with other components like brewer's yeast or soy flour)** to **one part syrup/honey** by volume.

- 15 & 21. 2 Parts of pollen substitute with 1 part syrup to make the patty. But how much microalgae goes into the dry powder pollen substitute before mixing with the liquid.

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- **Feeding Method:** The paste is pressed into thin patties (often between sheets of wax paper) and placed inside the hive, typically above the brood nest, where the nurse bees have direct access to it.

- **Advantages:** This method allows nurse bees to consume the protein source directly, which is crucial for producing royal jelly and feeding larvae. It mimics how bees consume natural pollen within the hive.

2. As a Liquid Supplement (Syrup Form)

Microalgae can also be suspended in sugar syrup for consumption, although bees may show a preference for patties.

- **Preparation:** Microalgae powder is mixed into a sugar syrup solution (e.g., a 1:1 or 2:1 sugar-to-water ratio).

- **Feeding Method:** The fortified syrup can be provided in standard hive feeders (internal or external).

- **Advantages:** This method is effective for delivering specific active compounds (like engineered antiviral agents) or for general nutritional support when colonies need a liquid feed boost.

- Footnote 16. Mixing with pollen, which the nurse bees are consuming for their own food, should help invigorate the nurse bees making them more enthusiastic about feeding.

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Key Considerations for Optimal Feeding:

- **Palatability is Key:** Bees can be picky eaters. Ensuring the microalgae is mixed well and presented in a familiar, palatable form is important for consumption. In some studies, bees preferred pure pollen diets but readily consumed the microalgae patties when compared to control diets without a protein source.
- **Consistent Supply:** For best results in promoting colony health and growth, the feed should be supplied consistently during periods of natural pollen dearth.
- Footnote 17. Consistent supply means "whenever supplemental feeding" is being done. During periods of extreme weather fluctuation supplemental feeding will even out the food sources brought into the hive. This tricks the queen into continual egg laying instead of slowing down during long cool or rainy periods in the spring even though flowers are blooming the bees are not flying.
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- **Direct Delivery to Nurse Bees:** Placing the feed close to the brood ensures that the nurse bees, who require the protein for larval development, can access it efficiently.
- Footnote 18. Direct delivery of algae may be the fastest way to achieve results (mixed in the patty). This will ensure the nurse bees are getting it and then passing it on to enhance the larval growth.
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- **Avoid Larval Overexposure:** Studies suggest feeding *extracts* of chlorella directly to larvae in laboratory conditions may cause issues; therefore, the most effective application is through adult worker bees who process the food naturally within the colony environment.
- 19. Bee bread as the supplement carrier avoids the direct larvae exposure Pollen and nectar (honey) processing to create and store the bee bread is step one. Nurse bee picking up the bee bread and mixing it with larva "rearing" enzymes and then feeding it to the is step 2. This removes the larvae from directly consuming the algae.
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- **Commercial Availability:** The technology is designed to be easily integrated into beekeepers' existing management practices using readily available commercial microalgae powder, without needing additional processing by the beekeeper.
- Footnote 20. These raw microalgae are available at your local health food store or in cheaper bulk through the computer. I paid $23 for 8 0z. Chlorella powder and $23 for 16 oz. of spirulina powder plus $15 shipping and handling. I won't know if this is a good deal until it works next April. My plan is to mix these together and then mix it with powdered pollen substitute which will be field fed to the entire apiary starting now so some of the wintered over bee bread will be available to larvae next spring. Hopefully there will be some medicinal effects on the adult bees this winter (or a waste of some money). Honey B Healthy additives can run about $15+ per 16 liquid ounce.
- This is all food for thought. Food for thought is dangerous, but I will lead the crazies.
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3. Add the dry Spirulina powder to the pollen substitute you normally use. Mix the Spirulina with your pollen substitute at not more than a 10% ratio (10lbs pollen Sub + 1lbs Spirulina) and feed directly your bees in your pollen sub feeder.

- Footnote 21. Do the math! 1 pound of powdered pollen substitute with 1/10 of a pound of microalgae powder. I guess you will need an accurate cooking scale (or your cocaine scale).

At least in tests, the researchers did not overload the honeybee with all these good chemicals (that are necessary for life) to the point of creating a poisonous diet. We must bear in mind, Arsenic is a natural chemical found in many soil samples and concentrated in some plants. But it does not become lethal until concentrated and fed to us.

PLEASE NOTE: This handout is simply food for thought. It was produced for informational purposes only and is not intended to be a direct advocacy for the use of Spirulina in any Beekeeper's Apiary or beehive as a food supplement. The purpose of this handout is simply to provide some highlights into some of the research being conducted nationally into ways to support and improve Honeybee survival and production. Several internet articles from various sources were used to create this paper using copy, cut, and paste procedures. Printed copies of the articles are available for loan out reading.