

*Like you, wild bird safety and health is critical to us at Sapphire Labs, and it is the primary reason for designing our products. We take great pride in creating products that protect wild birds for over 15 years.*



## Safety of Nectar Defender

When you are feeding the hummingbirds you love, you know that nectar will spoil quickly.

Hummingbird enthusiasts requested that we create a product to keep nectar fresh, but without the artificial preservatives found in other nectars. After extensively researching hummingbird diets, we found a nutrient that hummingbirds naturally consume, and surprisingly keeps nectar fresh even when added at an extremely low level.

Nectar Defender is an innovative new product, designed to promote the health of hummingbirds by preventing the known risks of nectar spoilage. It contains micronutrient copper to keep your nectar fresh and healthy naturally.

We love hummingbirds, and would never offer a product that was not tested and deeply researched to make sure it was completely safe and appealing for the birds you also love. So the answer is emphatically yes, it is safe.

Below is some of the abundant research, which shows that Nectar Defender is undeniably safe for hummingbirds.

### Safety Key Points (see following section for greater detail):

- Hummingbirds naturally consume micronutrient copper in their daily diet of insects and nectar. It is something they must have for their normal growth and development.
- Nectar Defender is well within the natural range of copper found in wild hummingbird's diet. The arthropods that hummingbirds eat can be many times the copper level in Nectar Defender. And, the copper level of Nectar Defender combined with arthropods is substantially within a hummingbird's natural nutrient range.
- Micronutrient copper has been proven to be safe for hummingbirds in long-term studies of hummingbirds' diet conducted by University of California Avian Scientists, and at zoo and wildlife rehabilitation organizations to successfully maintain the long-term health of their hummingbird colonies for years at a time.
- To ensure Nectar Defender is safe, the amount of micronutrient used in Nectar Defender is below the level tested in these long-term studies and below the level recommended by the Association of Avian Veterinarians.
- The safety of Nectar Defender has been approved by avian and animal scientists at major universities and other hummingbird experts.
- In a real world situation, hummingbirds will have multiple sources of natural flower and feeder nectar and as a result, when using Nectar Defender, the actual level of copper in their nectar diet will likely be less than the drinking water standard.
- Hummingbirds are protected from absorbing more copper than they need due to their bodies' natural biochemical regulation. Birds have a robust system to precisely maintain a healthy copper balance (copper homeostasis). In fact, copper will not even be absorbed from nectar in a bird's digestive system, unless the it is in need of copper nutrient.
- Micronutrient copper will not accumulate in the hummingbird's system, because any excess is rapidly excreted from their system.
- This micronutrient copper used in Nectar Defender is the same mineral supplement used for decades to provide essential trace minerals for birds and is approved for this use by the FDA and USDA. It is safety rated by the FDA as GRAS ("generally recognized as safe"), the safest rating given.
- Based on real world preference testing, hummingbirds prefer nectar with Nectar Defender just as much as nectar without.

- Nectar Defender protects the birds and prevents nectar spoilage naturally up to 2 weeks, even in hot weather. They will enjoy fresh nectar every time they visit the feeder between cleanings.



## Safety Details:

Hummingbird feeders normally have to be changed and cleaned every few days. Lab and field testing have shown that the micronutrient copper in Nectar Defender will keep your nectar fresh up to 2 weeks. To maintain a healthy feeder, we recommend cleaning it at least once every 2 weeks.

Most people do not realize that copper is a very common and ubiquitous element, naturally present in food, soil and water. Copper also has beneficial effects, and is something that all animals, including birds, must have for their normal growth and development. Hummingbirds consume micronutrient copper in their daily diet of insects and nectar. For example, a mosquito, is part of a hummingbird's diet, and has a copper content three times that of Nectar Defender. In truth, birds that do not consume an adequate level of copper encounter many serious health issues.

### Long-term testing of micronutrient copper in a hummingbird diet shows it is safe

An official hummingbird nectar diet, containing a recommended level of micronutrient copper, was established by University of California Avian Scientists for the long-term maintenance of hummingbirds. The study provided protein-supplemented nectar containing 8 ppm copper (25 ppm dry basis) for 3 months to captive hummingbirds. This level of copper was selected by the researchers to satisfy the copper micronutrient requirement of hummingbirds. There were no reported signs of copper related problems or toxicities by the researcher, and the birds displayed their normal behavior of preening and singing. (*Protein Requirements of Costa's Hummingbirds Calypte costae*, Ann T. Brice and C. Richard Grau, Department of Avian Sciences, University of California, Davis, *Physiological Zoology* 64 (2):611-626, 1991)

In another study, an official nectar diet containing 8 ppm copper (25 ppm dry basis) was created and used for the long-term maintenance of captive hummingbirds by University of California avian scientists. Anna's and Costa's hummingbirds were maintained on this diet for several years. On this diet and copper level, the hummingbirds thrived with no signs of problems. The birds molted normally and the males displayed singing. The birds ate the diet readily and they drank little supplementary water, from which it was concluded that the percentage of solids in the diet was not excessive. Birds were weighed routinely to confirm health, and body weights varied little over time. The researchers concluded that the hummingbirds' acceptance of the diet and health of the hummingbirds has provided a means to determine their requirements for nutrients. The diet has since been used by other zoos and wildlife rehabilitation organizations for the long-term maintenance other species such as Allen's (Selasphorus sasin), black-chinned (Archilochus alexandri), and ruby throated (A. colibri) hummingbirds. (*Hummingbird Nutrition: Development of a Purified Diet for Long-Term Maintenance*, A.T. Brice and C.R. Grau, Department of Avian Sciences, University of California, Davis, *Zoo Biology* 8:233-237 (1989))

Whole-diet hummingbird nectar products for the long term care of captive hummingbirds contains copper in the single digit ppm range as a micronutrient, so the acceptance that copper is needed near that nutrient level appears to be universal.

Additional diet references:

Avian food containing 8 ppm of copper is recommended by The Association of Avian Veterinarians for psittacine and passerine birds (*Exotic Bird Nutrition Expert Panel Nutrition and Management Committee of the Association of Avian Veterinarians, 1996*).

Micronutrient copper has been studied and used in domestic and wild bird feed for decades as a supplement, and approved by the FDA and USDA. General avian recommendations range from 4-50 ppm copper.

In the standard reference "Mineral Tolerance of Animals" the dietary micronutrient range recommended for birds is between 4 and 12 ppm. (*The National Academies Press, Second Revised Edition, 2005*).

### Nectar Defender is less than the recommended level, thus inherently safe

In order to ensure that the very low micronutrient level in Nectar Defender is within a safe range, it was designed to be even lower than the recommended level of copper in the official hummingbird diet and other recommended ranges. It is very far below the level that could possibly cause any health risks to hummingbirds.

Also, in a real world situation, hummingbirds will have multiple sources of natural flower and feeder nectar, likely dozens. If a hummingbird has even four other sources of nectar, then the level of copper in the hummingbird nectar diet will be less than the drinking water standard set by the EPA. In other words with the likely situation of a few other nectar sources, the result is a micronutrient level below even the safe level in drinking water.

### Nectar Defender is approved by avian experts

The safety of Nectar Defender has been approved by avian and animal scientists at major universities (such as Cornell University and University of California) and by hummingbird experts around the country. The reason for their approval, is their recognition that the micronutrient level in the product is within the recommended range and far below any level of risk.



**Nectar Defender is within the natural range of copper found in a wild hummingbird's diet.**

Copper is present in the foods hummingbirds consume in their natural diet. A substantial part of a hummingbird's diet is arthropods (insects and spiders), and can reportedly range from 10% to 80% of their diet depending on the time of year. Arthropods provide their main source of protein, vitamins, oils, fiber and minerals. Hummingbirds will eat flies, spiders, bugs, aphids, mites, leafhoppers, and flying ants. These arthropods contain a moderate amount of copper. For example mosquitoes, a common part of a hummingbird's diet, has a copper content of 23 ppm, three times higher than that of Nectar Defender. Other arthropods consistently contain copper, even up to 9 times higher than that of Nectar Defender. The level of copper in arthropods is not surprising, since their circulatory system contains copper-bearing proteins (mainly hemocyanin supergroup structures).

Since arthropods can be a large part of a hummingbird's diet, the range of copper in a wild hummingbird's natural diet can be significant. Arthropods range from 6 to 50 ppm copper, averaging roughly 20 ppm. Even with no other source of copper, 10% to 80% arthropod consumption means a wild hummingbird natural diet ranging from 2 to 16 ppm.

As noted above, hummingbirds will have several sources of nectar. Even if Nectar Defender was about half of the nectar consumed, the resulting range of insects plus nectar for 10% to 80% arthropod consumption would be 5 to 17 ppm, overlapping the 2 to 16 ppm natural range in the wild. In other words:

- Range of a hummingbird's diet, no Nectar Defender (est) : 2 to 16 ppm Cu
- Range of a hummingbird's diet with 50% Nectar Defender (est): 5 to 17 ppm Cu
- Range of a hummingbird's diet with 100% Nectar Defender (est): 7 to 17 ppm Cu

This means that Nectar Defender is well within the natural range of copper found in a wild hummingbird's diet. And, the copper level of Nectar Defender combined with arthropods is substantially within a hummingbird's natural range.

(Insect Composition: "Spider Ecophysiology", Wolfgang Nentwig, Universität Bern Springer Science & Business Media, Feb 15, 2013; "Feeding Captive Insectivorous Animals, Nutritional Aspects of Insects as Food" Nutritional Advisory Group, Nutrition Advisory Handbook, Bernard, J. Allen, M. and Ullrey, D., Michigan State University, East Lansing and National Zoological Park, Smithsonian Institution, Washington D.C.; "Complete Nutrient Content of Four Species of Feeder Insects", Mark D. Finke, Zoo Biology 00: 1–15, 2012; "Nutrient Content of Insects", Mark D. Finke, Encyclopedia of Entomology, 2008, pp 2623-2646; "Molecular Evolution of the Arthropod Hemocyanin Superfamily" Thorsten Burmester, Institute of Zoology, University of Mainz, Mainz, Germany; "Evolution of Arthropod Hemocyanins and Insect Storage Proteins (Hexamerins )" Jaap J. Beintema, et. al. Departments of Biochemistry, Marine Biology, and Biophysical Chemistry, University of Groningen. Insect Consumption: "A nesting hummingbird feeding solely on arthropods". MONTGOMERIER, D. AND C. A. REDSELL. 1980. Condor 82:463-464. "Frequency of arthropods in stomachs of tropical hummingbirds". REMSEN, J. V., JR., F. G. STILES, AND P. E. SCORR. 1986. Auk 103:436-441. )



**Hummingbirds are protected from absorbing more copper than they need due to copper homeostasis**

Birds and most animals, have robust systems for regulating copper input, and excreting any excess copper. Experts on the biochemistry of copper are in agreement that most organisms do not accumulate copper, because they have sophisticated and efficient copper homeostasis mechanisms that regulate uptake, distribution, sequestration and export of copper.

Copper levels are kept stable by multiple biochemical controls (homeostasis), including copper importers, copper chaperones, transcription factors, small metal binding proteins (metallothioneins), and copper exporters. For this reason, animals can tolerate a range of copper exposure with little effect. It is also the reason that, unless there is a genetic defect in the organism, copper does not bioaccumulate, even at elevated dietary copper conditions.

The basic mechanisms of copper regulation are understood, and common across multicellular organisms from fruit flies, to hummingbirds to humans. The first level of control is in the intestine, where copper will not be absorbed, unless copper transporters allow the movement of copper into the system. The amount of these transporters are regulated by the copper level in the organism. Therefore copper does not even enter the system from the intestines if it is not needed by the organism. Within the system, any excess copper is controlled by copper uptake proteins or metallothioneins, regulated by the metal-responsive transcription factor. Unused copper is temporarily stored in the liver, and any excess is removed by another copper transporter into the bile. The bile is then excreted via the normal process.

Actual dietary studies with domestic birds demonstrate the protective nature of copper homeostasis. When fed increasing levels of copper, birds do not show accumulation or any significant increase in the copper content of their blood or liver. The studies do show elevated copper levels in the bird's excrement, proving that the biocontrols keep the excess copper in the intestine, and restricted from entering the bird's system. The studies also show copper in the bile, supporting an active copper removal process.

For all of these physiologic reasons, it is difficult for hummingbirds to absorb more copper than they actually need. Nectar Defender is within the range of natural copper consumption, but a further protection to hummingbirds is the universal copper regulation. Even if an increase was present, hummingbirds would not see it reflected within their system, and definitely would not accumulate it.

("Ctr1 and its role in body copper homeostasis", Paul A. Sharp, *The International Journal of Biochemistry & Cell Biology*, Volume 35, Issue 3, March 2003, Pages 288–291; "A Copper-regulated Transporter Required for Copper Acquisition, Pigmentation, and Specific Stages of Development in *Drosophila melanogaster*", September 8, 2003, Hao Zhou, Ken M. Cadigan, and Dennis J. Thiele, *THE JOURNAL OF BIOLOGICAL CHEMISTRY* Vol. 278, No. 48, Issue of November 28, pp. 48210–48218, 2003; "Copper homeostasis in *Drosophila* by complex interplay of import, storage and behavioral avoidance", Balamurugan, K., et. Al. Institute of Molecular Biology, University of Zurich, *The EMBO journal*, vol 26, no 4, 2007. )

Some uninformed birders on the web have confused copper properties with iron properties. Iron can be an issue because it is the only common metal that cannot be excreted and therefore can accumulate in the avian system. However, copper is completely different both chemically and physiologically from iron. As detailed above, copper is well regulated and therefore it remains balanced, and does not accumulate according to published research and university avian scientists. (Klasing KC, Dierenfeld ES, Koutsos EA, *Avian iron storage disease: variations on a common theme? Zoo Wildl Med.* 2012 Sep;43(3 Suppl):S27-34.)

## **Nectar Defender is equally preferred to plain sucrose nectar**

Based on real world preference testing by ourselves and other groups, hummingbirds do not have a preference between plain nectar and nectar with Nectar Defender. This is not surprising, since nectar with Nectar Defender does not taste any different than untreated nectar to human subjects. Hummingbirds have lost their sweetness receptors, and taste sugar by their umami taste receptors - but based on preference testing probably cannot perceive a difference either.

One example is a preference test using 8 small feeders in different locations within a 50' by 60' area, monitored for consumption over two 5 day intervals. Half were filled with plain sugar nectar (1:4 ratio) and half were filled with sugar nectar plus Nectar Defender. To eliminate location and feeder differences, after 5 days the feeders were rinsed, and the contents switched to the other nectar.

The mean consumption of the plain sugar nectar was 21.3 mls, while the mean consumption of the Nectar Defender nectar was 22.2 mls. There was no statistically significant difference between the two nectars. Therefore there is no preference or aversion to Nectar Defender.

## **Why copper is needed**

Copper is an essential component of a number of enzymes including cytochrome, oxidase, lysyl oxidase, superoxide dismutase, tyrosinase, ceruloplasmin, and dopamine  $\beta$ -monooxygenase. Copper-dependent enzymes function in energy metabolism, maturation and stability of collagen and elastin, pigmentation, the antioxidant defense system, iron removal, and other biological processes.

Since copper is an essential nutrient, the greatest risk to birds is lack of copper in the diet. Too little copper may result in cardiovascular disorders (cardiac failure or rupture of the aorta), depigmentation, impaired keratinization, anemia, reduced growth, neonatal ataxia, bone abnormalities, and impaired immune responses.

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