

# Geranylgeraniol (GG) Reverses Pain, Gut Damage, and Mitochondrial Dysfunction in Diabetic Neuropathy

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May 28, 2026

## STORY AT-A-GLANCE

- › Researchers found that a naturally occurring compound called geranylgeraniol (GG) reduced diabetic nerve pain by 35% in rats even without significantly improving blood sugar control
- › Diabetic neuropathy involves far more than elevated glucose levels because gut barrier breakdown, mitochondrial dysfunction, and chronic inflammation all contribute to nerve irritation and pain sensitivity
- › GG improved tight junction proteins in the intestines, helping reduce the leakage of bacterial toxins that fuel inflammatory stress throughout the nervous system
- › Beneficial gut bacteria require properly tolerated carbohydrates and fermentable fibers to produce butyrate, a short-chain fatty acid that helps maintain the gut barrier and supports healthier nerve function
- › Daily habits that improve mitochondrial energy production, including removing seed oils, restoring healthy carbohydrate intake, getting regular sunlight exposure and improving sleep quality, help calm the inflammatory signals that keep nerves hypersensitive

Diabetic neuropathy affects up to 75% of adults with diabetes, yet most people understand it only as a complication of high blood sugar. Researchers from Texas Tech University Health Sciences Center argue in the *International Journal of Molecular Sciences* that framing neuropathy as a blood sugar problem misses most of what's actually driving the pain.<sup>1</sup>

The condition involves a cascade of interconnected failures – nerve damage, yes, but also gut barrier breakdown, mitochondrial dysfunction, and chronic inflammation – and treating it may require addressing all of them together. This distinction changes what solutions are even worth considering.

That's where a naturally occurring compound called [geranylgeraniol](#), or GG, enters the picture. It's already present in your body, it's found in common foods like fruits, vegetables, and grains, and it appears to work on the parts of this problem that glucose control doesn't reach.

Your body converts GG into a compound called geranylgeranyl pyrophosphate – think of it as a molecular building block your cells use to assemble energy machinery, repair membranes, and keep insulin signaling running smoothly. Without enough of it, those systems degrade quietly in the background.

Researchers tested whether supplementing with it could reduce nerve pain and restore cellular function through pathways that have nothing to do with glucose control, and what they found challenges some long-held assumptions about what diabetic neuropathy actually is.

## **Gut Repair Changed Nerve Pain Even When Blood Sugar Stayed High**

For the study, researchers investigated whether GG could reduce nerve pain, inflammation, and intestinal damage in diabetic rats.<sup>2</sup> GG helps support the systems your cells use to create energy and maintain healthy tissue function. The study examined whether improving mitochondrial function and gut integrity with GG could reduce diabetic neuropathy symptoms even without major changes in glucose control.

Researchers fed rats a high-fat diet, induced diabetes, and then supplemented one group with GG for six weeks. Instead of measuring only pain levels, they also tracked gut bacteria, inflammatory markers, [mitochondrial repair systems](#), and anxiety-like behaviors.

- **The diabetic rats developed widespread metabolic dysfunction** – Compared to healthy controls, the diabetic rats showed insulin resistance, impaired glucose tolerance, gut microbiome disruption, and signs of mitochondrial breakdown inside the colon. The researchers also observed anxiety-like behaviors, reduced movement confidence, and heightened sensitivity to touch, showing how deeply metabolic dysfunction affects the nervous system.
- **Pain sensitivity dropped by 35% after GG supplementation** – One of the biggest findings involved mechanosensitive pain, meaning pain triggered by touch or pressure. Researchers used the von Frey test, which measures how strongly an animal reacts to physical stimulation. Rats given GG showed a 35% reduction in pain sensitivity compared to untreated diabetic rats. In practical terms, the nerves became less reactive and less irritated.
- **The rats also behaved less fearful and anxious** – **Chronic nerve pain** affects emotional regulation alongside physical sensation. Untreated diabetic rats avoided open spaces and displayed behaviors tied to fear and anxiety. After GG supplementation, the rats explored open areas more often and spent more time there. That shift suggests GG improved neurological stress responses alongside pain sensitivity.
- **Blood sugar remained impaired despite the pain improvements** – The GG supplement did not significantly improve insulin resistance, glucose tolerance, or pancreatic beta-cell damage. Beta cells are the insulin-producing cells inside your pancreas. Even though glucose metabolism stayed impaired, pain levels, inflammatory markers, and mitochondrial function improved anyway.

Most diabetic neuropathy discussions focus almost entirely on glucose levels. This study showed that restoring mitochondrial function and intestinal integrity improved pain outcomes even while metabolic dysfunction remained present.

# Gut Bacteria and Mitochondrial Repair Reshaped the Pain Response

As part of the study, researchers measured claudin-3, a tight junction protein that helps seal the intestinal lining. Tight junctions work like protective seals between intestinal cells. Once those seals weaken, bacterial toxins leak into circulation and trigger immune activation throughout the body. Diabetic rats showed lower claudin-3 levels, while GG supplementation significantly increased them.

- **Lower gut permeability reduced inflammatory overload** — Once the [gut barrier](#) weakens, the immune system stays trapped in a chronic inflammatory state that worsens mitochondrial stress and nerve irritation. By improving tight junction integrity, GG reduced one of the upstream triggers driving the inflammatory cycle. That matters because many people with metabolic disease live in a constant low-grade inflammatory state without realizing the gut often sits at the center of the problem.
- **Several beneficial gut bacteria declined in diabetic rats** — The diabetic animals showed reduced levels of *Eubacterium coprostanoligenes*, *Lachnospiraceae*, and *Oscillospiraceae*. These bacteria help support the intestinal mucus layer and regulate anti-inflammatory signaling. At the same time, inflammatory-associated bacteria like *Clostridium sensu stricto* increased.
- **GG improved microbial diversity even without fully correcting dysbiosis** — The supplement didn't completely restore the gut microbiome, but it increased alpha diversity. Alpha diversity refers to the variety of microbes living inside the gut. Higher diversity usually reflects a more resilient and stable microbial environment. Think of it like strengthening the ecosystem inside your digestive tract so harmful organisms have a harder time dominating the environment.
- **The strongest improvements appeared inside the mitochondria** — Researchers measured markers tied to mitochondrial fusion, fission, repair, and turnover. Healthy mitochondria constantly merge, divide, and recycle damaged components to

maintain stable energy production. In the diabetic rats, this repair system became severely disrupted.

The GG supplement raised levels of two markers involved in mitochondrial fusion and the production of new mitochondria. More mitochondrial repair and renewal translates into stronger cellular energy production, which directly affects nerve stability and inflammation control.

- **Markers of mitochondrial breakdown dropped sharply** – Before supplementation, the diabetic rats showed elevated levels of markers that reflect excessive mitochondrial fragmentation and stress-driven recycling of damaged mitochondria. GG lowered these markers. That shift indicates the cells moved away from a breakdown state and back toward more stable energy production.

The researchers also found lower TNF-alpha levels after GG supplementation. TNF-alpha acts like a cellular alarm signal that amplifies inflammation and pain sensitivity. Once TNF-alpha stays elevated, nerves become more reactive and irritated. Lowering that inflammatory pressure helps calm the nervous system and reduce hypersensitivity.

## **Support Mitochondrial Repair and Gut Integrity to Calm Diabetic Nerve Pain**

The findings from this study point toward a clear direction. GG worked not by fixing blood sugar, but by restoring the two systems that keep nerve pain locked in place – mitochondrial function and gut barrier integrity. When those systems stabilized, pain signals dropped, inflammatory overload eased, and the nervous system became less reactive. That gives you a practical framework for what to address next.

GG helps your cells maintain the machinery required to produce energy and repair damaged tissue. The steps below build on that same logic – starting with GG itself, then targeting the mitochondrial and gut conditions the research identified as central to the pain cycle.

**1. Increase your intake of GG and use the right form** – GG naturally occurs in foods like tomatoes, carrots, olives, and some grains, but supplemental forms provide far more concentrated support. Most commercial GG supplements contain 150 milligrams (mg) to 300 mg per softgel.

Look for supplements containing "GG-Gold" or similar branded forms of trans-geranylgeraniol derived from annatto seeds because these are the most studied forms. GG can be taken with or without food. GG has an excellent safety profile. That said, always consult with a health care provider familiar with your medical history before starting any new supplement.

**2. Feed your cells the raw materials required for nerve repair** – Your nerves don't heal in a low-energy environment. Every repair process inside your body depends on stable adenosine triphosphate (ATP) production, and ATP production drops sharply when your metabolism stays trapped in chronic stress mode. Carbohydrate restriction and ultraprocessed diets often worsen metabolic dysfunction because they suppress mitochondrial energy production instead of restoring it.

Most adults do best with roughly 250 grams of healthy carbohydrates daily, and active individuals often require more. The key is choosing carbohydrates your gut tolerates well while rebuilding metabolic flexibility. Start with easier-to-digest options like whole fruit and white rice. As digestion and gut function improve, gradually add more root vegetables and well-tolerated higher-fiber carbohydrates.

Protein intake also matters. Aim for about 0.8 grams per pound (or 1.76 grams per kilogram) of lean body mass, with one-third coming from [collagen-rich sources](#) like slow-cooked meats or bone broth. Collagen provides glycine and other amino acids tied to connective tissue repair, gut barrier support, and nervous system stability.

**3. Repair the gut environment that keeps inflammation switched on** – Diabetic neuropathy often overlaps with bloating, unstable digestion, food sensitivities, and fluctuating energy because the gut barrier and microbiome become disrupted

alongside the nervous system. Once your intestinal lining weakens, bacterial toxins leak into circulation and trigger chronic inflammatory stress that aggravates nerve irritation.

One of the most important goals is restoring the bacteria that produce short-chain fatty acids like **butyrate**. Butyrate serves as a primary fuel source for colon cells and helps maintain the oxygen-free environment beneficial gut bacteria require to survive. Once butyrate production drops, harmful oxygen-tolerant bacteria gain ground, gut permeability worsens, and inflammatory stress increases throughout the body.

That is where carbohydrates and fiber become important. Beneficial gut bacteria rely on carbohydrates and fermentable fibers to produce butyrate. Without enough properly tolerated carbohydrates, your microbiome struggles to rebuild itself and colon cells lose an important fuel source needed to maintain the gut barrier. The problem is that many people with metabolic dysfunction and gut damage tolerate large amounts of fiber very poorly in the beginning.

The rebuilding process works best gradually. As mentioned, start with easy-to-digest carbohydrates such as fruit and white rice. After tolerance improves, slowly introduce additional root vegetables and higher-fiber foods so beneficial bacteria have more material to produce butyrate without overwhelming digestion.

Aggressive high-fiber diets too early often backfire because excessive fermentation increases endotoxin production and intestinal irritation in already damaged guts. Seed oils deserve special attention as well because excess **linoleic acid** (LA) damages mitochondrial membranes and intensifies oxidative stress throughout the gut and nervous system.

Removing soybean oil, canola oil, sunflower oil, and other vegetable oils helps improve mitochondrial function for increased cellular energy. Replace them with stable fats like tallow, ghee, or grass fed butter.

**4. Use light exposure and targeted nutrients to improve nerve resilience** – Your nervous system depends on nutrients that support electrical signaling, tissue repair, and mitochondrial energy production. **Vitamins B1, B6, and B12** play direct roles in maintaining healthy nerve communication and protecting the myelin sheath surrounding nerves. Deficiencies in these nutrients strongly correlate with chronic nerve pain.

Vitamin D also influences nerve function, insulin sensitivity, and inflammatory regulation.<sup>3</sup> Regular **sunlight exposure** supports healthy vitamin D levels while improving circadian rhythm signaling and mitochondrial energy production. Morning outdoor light exposure helps reset your biological clock, while gradual midday sun exposure supports deeper metabolic repair.

Avoid intense sun exposure from 10 a.m. to 4 p.m. until you've reduced seed oil intake for at least six months, since high LA levels increase your skin's sensitivity to the sun.

**Red light therapy**, also called photobiomodulation, works through a similar energy-supportive mechanism. Specific red and near-infrared wavelengths stimulate mitochondrial function directly inside tissues, improving circulation and lowering inflammatory stress within damaged nerves. Consistent exposure often improves pain sensitivity, recovery, and mobility because healthier mitochondria produce more cellular energy for tissue repair.

**5. Lower the daily inflammatory signals that keep nerves hypersensitive** – When inflammatory signaling stays elevated long term, nerves become overly reactive and pain thresholds drop sharply. Daily habits either calm or amplify those signals. Walking after meals improves glucose handling and circulation. Strength training twice a week improves mitochondrial function and insulin sensitivity.

Sleep quality also plays a major role because poor sleep raises stress hormones and inflammatory signaling that keep your nervous system stuck in a hyperreactive state. Alcohol also deserves attention because it damages mitochondria, worsens

gut permeability, and intensifies inflammatory stress throughout the nervous system.

The goal of each of these steps is the same: reduce the inflammatory load your nervous system is carrying, restore the cellular energy it needs to repair itself, and give your gut the conditions it needs to stop feeding the fire. When all three stabilize together, the pain signals that once seemed permanent often quiet down, sometimes significantly.

## **FAQs About GG and Diabetic Neuropathy**

**Q: What is GG, and why does it matter for diabetic nerve pain?**

**A:** GG is a naturally occurring compound found in foods like tomatoes, carrots, olives, and certain grains. Your body uses it to produce compounds involved in mitochondrial energy production, cellular repair, and insulin signaling. In the study, GG reduced pain sensitivity, improved gut barrier integrity, and lowered inflammatory signaling in diabetic rats, even though blood sugar control stayed impaired.

**Q: How does gut health affect diabetic neuropathy?**

**A:** The study showed that diabetic neuropathy involves more than damaged nerves. Gut barrier dysfunction and microbiome imbalance also play major roles. Once the intestinal lining weakens, bacterial toxins leak into circulation and trigger chronic inflammation that aggravates nerve irritation. Researchers found that GG improved tight junction integrity and increased microbial diversity, which helped calm inflammatory stress linked to nerve pain.

**Q: Why are mitochondria important in diabetic neuropathy?**

**A:** Mitochondria are the energy-producing structures inside your cells. Your nerves require enormous amounts of energy to maintain healthy signaling and repair tissue damage. The researchers found that diabetic rats showed major signs of mitochondrial breakdown, while GG improved markers tied to mitochondrial repair, fusion, and biogenesis. Healthier mitochondria produce more ATP, which helps stabilize nerves and lower inflammatory stress.

**Q: Why does the article recommend carbohydrates if gut health is damaged?**

**A:** Beneficial gut bacteria rely on carbohydrates and fermentable fibers to produce butyrate, a short-chain fatty acid that fuels colon cells and helps maintain the gut barrier. The key is introducing carbohydrates gradually and choosing easier-to-digest options first. Whole fruit and white rice often work better early on because many people with gut dysfunction tolerate high-fiber diets very poorly at first.

**Q: What daily habits help calm hypersensitive nerves?**

**A:** Daily habits strongly influence inflammatory signaling and mitochondrial function. Walking after meals improves circulation and glucose handling. Strength training supports mitochondrial energy production and insulin sensitivity. Sleep quality also matters because poor sleep raises inflammatory stress hormones.

Sunlight exposure, red light therapy, and removing seed oils help support healthier mitochondrial function, while alcohol worsens gut permeability, mitochondrial damage, and nerve irritation.

## Sources and References

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- [1, 2 International Journal of Molecular Sciences 2025, 26\(24\), 12133](#)
- [3 Dove Press December 19, 2021; 2021: 3865-3875](#)