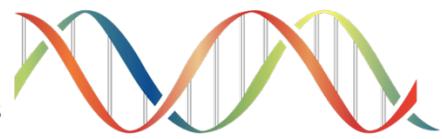




**Community BioRefineries**  
The Epitome of American Innovation



# GRAS Chlorogenic Acid Explained: Safety, Benefits, and Key Applications

*"Rien ne se perd, rien ne se crée, tout se transforme."* which translates to "Nothing is lost, nothing is created, everything is transformed."

~ *Antoine Lavoisier*

*By Scott Hewitt CEO and Vincent R. James Ph.D. (A.B.D.) CTO Community BioRefineries, LLC –2025*

In his seminal 1789 work, "Traité Élémentaire de Chimie," Antoine Lavoisier, often hailed as the father of modern chemistry, introduced the law of conservation of mass, demonstrating through precise experiments that matter is neither created nor destroyed in chemical reactions but merely transformed. "Nothing is lost, nothing is created, everything is transformed." This principle revolutionized science and parallels the transformative activities in biorefineries, where agricultural waste like potato peels is repurposed into biofuels and high-value products such as chlorogenic acid, embodying sustainable resource utilization.

Lavoisier's axiom does more than frame the philosophical foundation of chemistry—it provides the conceptual bridge into the modern biorefinery. If matter is always transforming, then the task of the 21st-century biochemist is to direct that transformation with precision, purpose, and safety. Nowhere is this more evident than in the valorization of the whole potato plant, where phenolics, fibers, proteins, and sugars are not discarded but reorganized into high-value molecules.

Chlorogenic acid (CGA), a polyphenol long concentrated in potato peels, exemplifies the principle: a molecule whose defensive role in plants becomes a functional ingredient for human health when stewarded through the right biological system. To understand what Community BioRefineries (CBR) achieves in shifting CGA production toward GRAS-compliant systems (Generally Regarded As Safe), we begin by examining CGA itself—its safety, its biological power, and its role as a cornerstone in the next generation of safe bioproduct manufacturing. Chlorogenic acid contains no chlorine ions, but rather, exhibits a greenish tint which is at the source of its designation.

Chlorogenic acid (CGA) is a potent polyphenolic compound found in various plants. It serves as a key secondary metabolite for defense against environmental stressors such as pathogens and UV radiation. CGA has long been valued as a component in potato peels, constituting a notable portion of their dry weight. This is due to its multifaceted health benefits, including antioxidant activity that scavenges reactive oxygen species (ROS), support for blood sugar regulation, anti-inflammatory effects, and neuroprotective properties that help mitigate issues in models of Alzheimer's disease.

Historically, CGA has been sourced through plant extraction, but this approach faces challenges like low availability and supply chain issues from seasonal crops. Community BioRefineries (CBR) focuses on sustainable

production of CGA using GRAS-compliant methods, ensuring safety for direct use in food applications without extensive additional processing. CBR transforms agricultural waste into safe, high-value products, aligning with FDA regulations for GRAS status.

CBR produces CGA as a powerhouse in the food science industry. Its GRAS status unlocks immense value as a natural antioxidant additive that inhibits lipid oxidation to extend shelf life in products like fish, sunflower butter, and baked goods. It acts as a metal chelator to prevent spoilage and enhances nutritional profiles in fortified yogurts and beverages by combating oxidative stress. It supports clean-label claims for functional foods targeting metabolic syndrome, enabling direct incorporation into products. This taps into a growing nutraceutical market projected to exceed \$200 million by 2031. CBR's approach aligns with a zero-waste paradigm, where residuals are converted into biofuels and solvents like bio-acetone, bio-butanol, bio-ethanol, and bio-hydrogen, creating an energy-neutral operation and leading to a shift in sustainable manufacturing.

## **Abstract**

The imperative for sustainable and safe food ingredients in the bioeconomy has led to innovative biorefinery designs that prioritize Generally Recognized as Safe (GRAS) products. This article highlights what the Community BioRefinery (CBR) in Wisconsin achieves in producing GRAS-compliant chlorogenic acid (CGA). CGA is a polyphenolic ester with antioxidant, anti-inflammatory, and metabolic health benefits, highly valued in nutraceuticals, cosmetics, and pharmaceuticals. The global market is valued at around USD 150 million in 2024 and projected to reach over USD 200 million by 2031 at a CAGR of about 3.89%. Traditional plant-based CGA sourcing faces availability and stability issues, while CBR's methods ensure safe, scalable production for human consumption. CBR transforms biomass like potato peels into CGA and other products, enhancing sustainability through zero-waste operations and integration with biofuel production. This approach offers economic benefits, environmental advantages, and compliance with regulations, positioning CBR to supply safe CGA while advancing bio-economies.

## **Introduction**

The bioeconomy is a transformative framework that leverages biological processes to produce goods from renewable resources, addressing global sustainability challenges including climate change and resource scarcity. Biorefineries are at the heart of this framework, converting biomass into fuels, chemicals, and materials with environmental benefits. The Community BioRefinery (CBR) in Wisconsin exemplifies this by valorizing agricultural waste such as potato peels, cranberry pomace, cheese whey, and hemp materials into biofuels, food ingredients, and co-products. With Wisconsin's potato industry generating millions of tons annually, CBR's system emphasizes zero-waste principles, projecting significant revenue while producing sustainable aviation fuel (SAF), heart-friendly oils, bio-plastics, and high-value compounds like CGA.

Chlorogenic acid (CGA) offers a high-value diversification opportunity for biorefineries. It is a natural polyphenolic compound that confers strong antioxidant capabilities by scavenging reactive oxygen species (ROS) through its structure. CGA's applications include metabolic regulation for diabetes control, anti-inflammation, neuroprotection, cardiovascular health, and enhancement of collagen and UV protection in cosmetics. In food, it serves as a preservative. The CGA market is robust, valued at approximately USD 150 million in 2024 and expected to grow to over USD 200 million by 2031, driven by demand for natural antioxidants in clean-label products. North America and Europe lead due to health focus, with growth in Asia-Pacific.

Background on Chlorogenic Acid Safety and Biological Functions CGA is a hydroxycinnamic acid derivative recognized for its safety in food and beverage applications, as seen in GRAS-affirmed coffee extracts and green coffee products. Biologically, CGA's antioxidant activity inhibits lipid peroxidation and mitigates oxidative stress-

related diseases. For metabolic health, it reduces glucose spikes. Anti-inflammatory effects include cytokine reduction. Neuroprotection involves plaque reduction, and cardiovascular benefits include cholesterol management. Other roles encompass metal chelation and fortification of foods like yogurt for improved nutrition. Research highlights CGA's potential in potato peels, enabling waste valorization into functional foods.

**Market Dynamics and Sourcing Challenges** CGA's natural status fuels its market in supplements, drinks, and cosmetics. Projections indicate growth to over USD 200 million by 2031 at around 3.89% CAGR. Sourcing from potato peels or coffee is challenging due to instability and supply volatility, but CBR addresses this by producing stable, GRAS CGA from waste streams.

### **What CBR Does in GRAS Chlorogenic Acid Production?**

CBR excels in producing GRAS CGA through sustainable methods, outperforming traditional approaches in regulatory compliance and scalability for human consumption. CBR's biorefinery transforms potato waste into CGA, ensuring safety and enabling direct use in food products like functional beverages, fortified yogurts, and antioxidant supplements.

**Combination with Biomass Processing** CBR processes biomass to create high-quality outputs, boosting CGA availability while converting residuals into biofuels. This creates additional nutraceuticals and bio-based products from potato waste, including:

- Polyphenols and Flavonoids: Antioxidants for supplements.
- Dietary Fibers/Prebiotics: For gut health products.
- Protein Isolates: For plant-based foods.
- Bio-Based Chemicals: For preservatives, e.g., Bio-Propionic Acid.
- Bioenergy and Biomaterials: For clean energy and materials. This expands the portfolio, creating higher-value GRAS products from the whole potato plant.

**Background on Biofuel Production:** CBR produces biofuels like bio-acetone, bio-butanol, bio-ethanol, and bio-hydrogen from waste, yielding renewable energy sources that power operations and support sustainability.

**Feasibility of Operations:** CBR's modular design allows for diversified production, creating complementary outputs like GRAS CGA and biofuels.

**Potential Benefits Economic:** Revenue from CGA and biofuels. **Sustainability:** Zero-waste operations. **Scalability:** Supports expansion. **Innovation:** Leadership in bioeconomy.

**Key Challenges and Mitigations:** CBR mitigates challenges like contamination through standard practices, ensuring biosafety and resource efficiency. The CBR process creates zero waste from beginning to end, also using no heat or chemicals.

**Implementation Overview:** CBR plans, sets up, engineers, operates, and budgets for sustainable production, achieving compliance and efficiency.

**Case Studies:** Precedents from industry leaders demonstrate integrated fermentation for diverse products.

**Conclusion** CBR's production of GRAS CGA transforms biorefineries, setting a benchmark for sustainable, safe manufacturing.

**Explanation of Biofuel Production and GRAS Status of Its Bio-Based Products:** Biofuel production at CBR yields bio-acetone, bio-butanol, bio-ethanol, and bio-hydrogen from biomass. These purified products achieve GRAS status for food uses:

- Bio-Ethanol: Used in beverages and extracts.
- Bio-Acetone: As a solvent in processing.
- Bio-Butanol: In flavors.
- Bio-Hydrogen: In food processing. These versatile, bio-based products reduce carbon footprints and enable sustainable integration.

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