

Amino acid cost and supply chain analysis for cultivated meat



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About GFI

The Good Food Institute is a nonprofit think tank working to make the global food system better for the planet, people, and animals. Alongside scientists, businesses, and policymakers, GFI's teams focus on making plant-based, fermentation-enabled, and cultivated meat delicious, affordable, and accessible. Powered by philanthropy, GFI is an international network of organizations advancing alternative proteins as an essential solution needed to meet the world's climate, global health, food security, and biodiversity goals. All of GFI's work is made possible by gifts and grants from our global community of donors. If you are interested in learning more about giving to GFI, contact philanthropy@gfi.org. To learn more, please visit www.gfi.org.

Executive summary

Unlocking a cost-effective amino acid supply is essential to scaling the cultivated meat (CM) industry. Amino acids represent a significant cost driver for CM production, due not only to the large quantities required, but also the complex supply chain needed to deliver them at the scale and suitability for food applications.

This white paper evaluates pathways to supply amino acids at the cost and volume required for a competitive cultivated meat industry. Through a first-of-its-kind analysis of future amino acid requirements, alternative sourcing strategies, and real-world price data, it equips stakeholders—from amino acid suppliers to CM producers—with the insights needed to prioritize the most impactful research and supply chain solutions as the CM industry scales.

This report demonstrates that while amino acids remain a major cost consideration, they are not an insurmountable financial barrier. With proactive production scale up, innovation in low-cost source materials, and alignment on clear regulatory requirements, the cultivated meat industry is well-positioned to unlock more affordable, scalable, and sustainable protein production.

Approach

1. Collected data and insights from structured interviews with stakeholders across the supply chain, including amino acid suppliers, cell media formulators, cultivated meat producers, and hydrolysate experts.
2. Modeled total and individual amino acid usage to produce 250 kilotonnes (kTA) of CM using commercially-relevant media formulations and estimates of amino acid requirements (200–650 g total AA/kg CM).
3. Estimated the amino acid cost contribution per liter of media and per kg of CM across two food-grade amino acid price tiers based on real-world quotes and one feed-grade price tier derived from aggregate supplier data.
4. Assessed the potential of 50 raw materials and hydrolysates to supply bulk amino acids and calculated price thresholds for hydrolysates to be competitive with amino acids derived from fermentation.

Key Findings

1

Amino acid costs are significantly lower than previously estimated

Real-world prices for food- and feed-grade amino acids are up to 10× lower than the figures used in a previous, highly-cited study (Humbird 2021). If the industry can source amino acids at lower-tier food-grade prices and achieve efficient production, amino acid cost contributions could fall below \$5/kg of cultivated meat—a major improvement over previous estimates of ~\$18–\$19/kg, which accounted for up to half the total cost of cultivated meat production (Humbird 2021). Total amino acid cost contributions to commercially-relevant media ranged from \$0.02 to \$0.17/L depending on the formulation and price (Figure 1). This suggests total media costs under \$0.20/L are achievable, aligning with recent reports from companies in the sector. These updated amino acid price estimates should now serve as the most realistic baseline for future techno-economic and media cost modeling.

Amino acid cost contributions to FSF4 media
(\$/L)

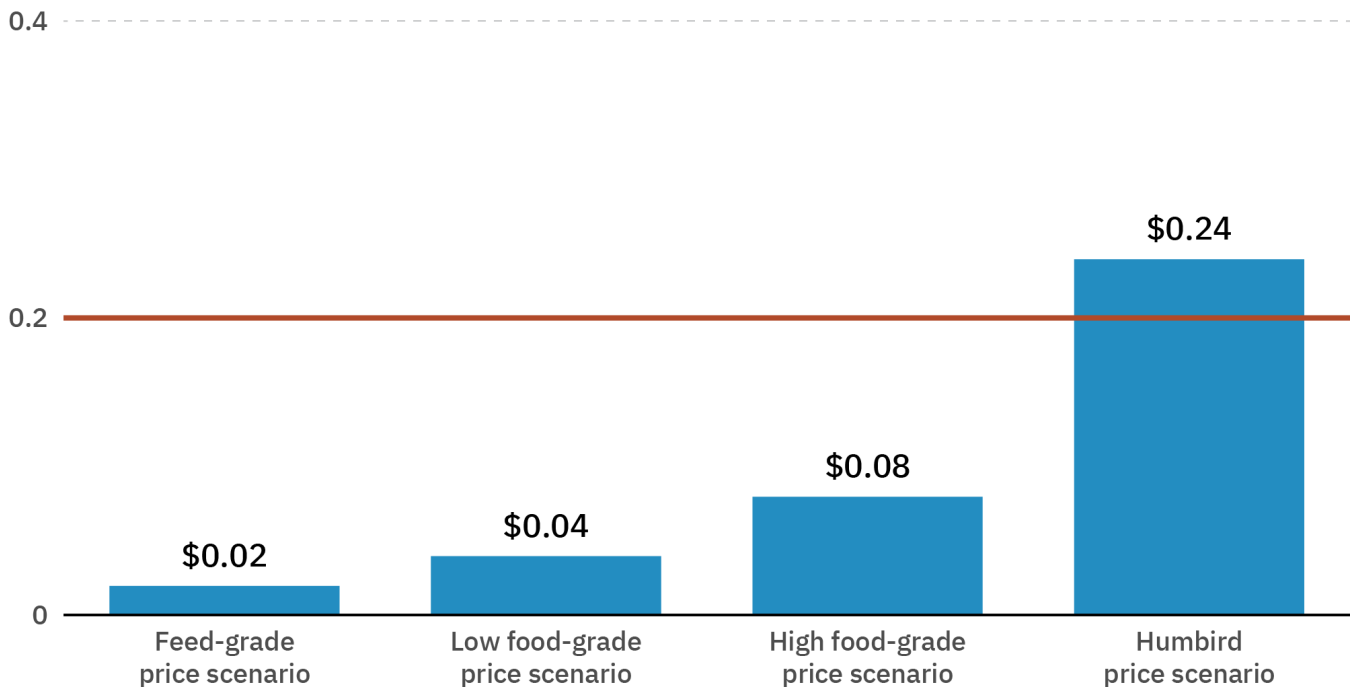


Figure 1. Total amino acid cost contributions to a commercially-relevant media formulation across four different price scenarios, with a red reference line at \$0.20/L to represent recent reports from companies in the sector. Data for an additional media formulation are shown in Figure 6.

2

Projected amino acid requirements could strain global supply

Although current amino acid supply and media manufacturing capacity are adequate for today's needs, this could quickly change in the future. At a future production volume of 250 kTA of cultivated meat, which equates to less than 1% of current global meat consumption, total amino acid requirements could reach ~50–163 kTA. Arginine, glutamine, and serine are each projected to exceed 10,000 MT/year, with eight additional amino acids requiring at least 2,200 MT/year. Asparagine, glutamine, histidine, proline, serine, tyrosine, and, to a lesser extent, leucine and isoleucine, were identified as high-risk for future supply bottlenecks due to future demand potentially outstripping current production volumes.

3

Hydrolysates hold strong long-term potential despite limitations

Hydrolysates and raw materials are consistently deficient in key amino acids like glutamine, arginine, cystine, serine, and asparagine, necessitating supplementation. Additionally, a single hydrolysate is unlikely to practically supply the remaining amino acids, likely requiring blending of two or more hydrolysates. Even so, several blends of hydrolysates were able to supply up to 60% of the required amino acids in modeled scenarios. To compete with fermentation-derived amino acids, hydrolysate blends would need to cost between \$1.51–\$11.27/kg hydrolysate. Batch-to-batch variability, solubility issues, and limited compositional data remain barriers to widespread adoption. While there is enthusiasm for hydrolysates and current testing within R&D programs, near-term CM products are unlikely to utilize them for amino acid supplementation until these challenges are resolved.



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Six amino acids pose outsized cost and supply risks

Six amino acids—serine, glutamine, asparagine, histidine, proline, and arginine—emerged as the most problematic due to high inclusion rates, elevated prices, low global production volumes, or manufacturing complexity (**Figure 2**). Serine stood out, contributing between ~16-38% of total amino acid costs in media. Furthermore, most of these amino acids are difficult to replace with hydrolysates and are likely to remain reliant on fermentation. Strategic efforts to improve production efficiency, diversify sourcing, and reduce costs for these high-impact inputs will be critical for long-term scalability.

High-risk amino acids

	Cost driver	Potential supply bottleneck	Difficult to replace with hydrolysate
Arginine	●		●
Asparagine	●	●	●
Cyst(e)ine	●		●
Glutamine	●	●	●
Histidine	●	●	
Isoleucine		●	
Leucine		●	
Proline	●	●	
Serine	●	●	●
Tyrosine		●	

Figure 2. High-risk amino acids. Heatmap summary of key results from the analysis, which shows the overlap in amino acids that are cost drivers, in limited supply, and difficult to replace with hydrolysates. Lighter shades indicate lower risk.

Calls to action

Cultivated meat has the potential to transform protein production by significantly reducing its environmental footprint, improving public health, and mitigating the ethical and social impacts of conventional meat. Achieving price parity is a critical step toward realizing these public benefits at scale, and amino acid cost and supply challenges must be addressed to unlock the full potential of cultivated meat. To that end, coordinated action is needed across the ecosystem.

The following calls to action outline specific steps that amino acid suppliers, researchers, cultivated meat companies, policymakers, and nonprofits can take to accelerate progress and ensure a resilient, affordable, and scalable amino acid supply chain for cultivated meat.

Amino acid suppliers

1. Actively monitor global cultivated meat production and proactively plan capacity to meet growing amino acid demand, especially for at-risk amino acids (e.g., asparagine, glutamine, histidine, proline, serine, and tyrosine).
2. Improve fermentation productivity and yields for high-risk amino acids such as arginine, asparagine, glutamine, histidine, proline, serine, and tyrosine.
3. Alongside CM companies and regulatory experts, support the co-development of “CM-grade” amino acid input specifications that are fit-for-purpose, standardizing criteria for endotoxin thresholds, heavy metals, microbial contamination, and other impurities of concern, to streamline documentation and regulatory review.
4. Share production volumes for amino acids. The true production volume of most amino acids suitable for cultivated meat is not currently known, and improved data will be necessary to continually refine which amino acids may be limited in supply.
5. Share updated life cycle inventory data for real-world, food- and feed-grade amino acid production and integrate renewable energy to reduce environmental impact.

Academic researchers

1. Develop and publish empirical data from commercially relevant bioprocesses to refine the feed conversion ratio of cultivated meat and key substrates such as glucose, glutamine, and other amino acids.
2. Use the hydrolysate modeling framework from this report to narrow the search space for high-potential blends of hydrolyzed raw materials for experimental validation.
3. Develop hydrolysis protocols that make hydrolysates a cost-competitive amino acid source (\$1.51–\$11.27/kg hydrolysate) compared with fermentation-derived amino acids.
4. Generate open-access datasets on hydrolysate composition and performance to enable artificial intelligence (AI) and machine learning (ML) tools for media optimization.
5. Collaborate with amino acid suppliers to update environmental impact data for food- and feed-grade amino acid production and integrate it into future LCA models.
6. Investigate metabolic and cell engineering strategies to improve fermentation yields and CM feed conversion ratios, reducing the cost burden of high-impact amino acids such as arginine, asparagine, glutamine, histidine, proline, serine, and tyrosine.

Cultivated meat companies

1. Co-develop “CM-grade” amino acid standards with amino acid suppliers, establishing fit-for-purpose criteria for amino acid quality to streamline documentation and regulatory compliance. Foregoing such an effort in favor of defaulting to higher-grade inputs could unnecessarily constrain innovation and prevent cost-competitive production at commercial scales.
2. Publish commercially relevant media formulations, including differentiation media, to improve shared modeling and supply chain planning.
3. Publish empirical data from commercially relevant bioprocesses to determine the feed conversion ratio of cultivated meat and key substrates such as glucose, glutamine, and other amino acids.
4. Explore hybrid media strategies that integrate hydrolysates and fermentation-based amino acids for long-term cost and sustainability gains.
5. Collaborate across the sector to establish pooled procurement strategies that create clear, aggregated demand signals for high-risk amino acids. Parallel development of CM-grade standards can ensure the entire supply chain is operating under the same expectations.

Governments, policymakers, and regulatory agencies

1. Support the development and recognition of “CM-grade” amino acid standards to streamline regulatory reviews and enable cost-effective sourcing.
2. Establish global leadership in cultivated meat by creating incentives for domestic amino acid manufacturing, including de-risking CapEx burden through grants, tax incentives, and low-interest loan programs. Onshoring amino acid manufacturing can reduce the dependence and risk of relying on concentrated international supply chains while creating new jobs and economic opportunities to leverage local biomass and feedstocks for amino acid fermentation.

Nonprofits and trade associations

1. Acquire and open-source media formulations and other IP (e.g., cell lines and bioprocess data) from defunct startups to support sector-wide transparency and modeling.
2. Facilitate pre-competitive R&D by funding projects that validate hydrolysate blends, optimize raw material sourcing and processing, and characterize functional performance.
3. Convene stakeholders to finalize and promote adoption of “CM-grade” media input standards and help align industry expectations with regulatory needs.
4. Support the creation of shared databases for amino acid production volumes, hydrolysate performance, and environmental impacts to guide future modeling and investment.