Good Food Institute

TECHNICAL SUMMARY

Plant-based meat techno-economic analysis



Authors

Nikhita Mansukhani Kogar, PhD,
Principal Scientist, Plant-based

Daniel Gertner, Manager,
Industry Economics and Supply Chain

Amanda Bess, PhD,
Senior Analysis Program Manager

*Corresponding author: nikhitak@gfi.org

Graphic design: Kelli Comsigt, Joe Gagyi, Emily Hennegan

Copy editing: Tara Foss

Suggested citation: Kogar, N. M. D. Gertner, and A. Bess. Technical summary: Plant-based meat techno-economic analysis. Washington D.C.: Good Food Institute. 2026. https://doi.org/10.62468/zmnt7666

The report summarizes the key results, interpretation, and recommendations of the plant-based meat techno-economic analysis conducted in partnership with Next Rung Technology. The full technical white paper with detailed model methodology, inputs, assumptions, and results, can be found here and referenced as:

Ashizawa, R., A. Haeger, J. Wimble, K. Trinidad, J. Ellersick. Plant-based meat manufacturing: A commercial scale TEA of extrusion and production formulation facilities. Washington D.C.: Good Food Institute. 2026. https://doi.org/10.62468/rphc5799

Regional Case Study Partners

We thank the following GFI colleagues for their invaluable contributions to company outreach, data collection, and analysis to gather and adapt regional data for this analysis. Their efforts were essential to making the regional case studies possible.

- **Graziele Grossi Bovi Karatay, PhD,**
  Science & Technology Senior Specialist, GFI Brazil
- **Gabriel Mesquita,**
  ESG Analyst, GFI Brazil
- **Raquel Casselli,**
  Corporate Engagement Director, GFI Brazil
- **Chandana Tekkatte,**
  Head of Science and Technology, GFI India

Acknowledgments

Data Partner: Bühler Group

Bühler Group is one of the largest providers of industrial processing solutions and serves billions of people every day through its food-production equipment and mobility-part-producing technology. Every day, two billion people enjoy foods produced on Bühler equipment, and one billion people travel in vehicles with parts manufactured with Bühler solutions.

Bühler Group provided essential industry data and technical expertise that strengthened the real-world basis of this analysis, including block flow diagrams, process parameters, mass balance, and price estimates for commercial-scale low-moisture and high-moisture extrusion systems using soy protein concentrate. These data were essential to ensuring that the techno-economic model in this analysis accurately reflected commercial-scale extrusion systems and real-world operating conditions.

The authors thank Stefan Prockl, Lukas Frei, and Christian Kern for their collaboration and support.

Expert interviewees

This analysis would not have been possible without the generous contributions of our interviewees who shared their time, information, data, and insights. We extend our sincere appreciation to all who participated. The following list includes those individuals who consented to be named and does not encompass those who contributed anonymously. Expert input informs our analysis but does not constitute endorsement of our findings.

Alexander Lamm

Lemmings BBQ & Kitchen

Amanda Schaible,
Synthesis Capital

Anthony Warner,
New Food Innovation

Benjamin Voiry,
Head of Marketing, Plant Proteins, Roquette

Chris Gregson, PhD,
Greenstalk Food Consulting & Paragon Pure Inc.

Christie Lagally Bradburn,
Founder & CEO, Rebellyous Foods

Crispin Howitt, PhD,
CSIRO

Da Chen, PhD,
Department of Food Science, Purdue University

Daring Foods, Inc.

Frédéric Baudouin, PhD,
IMPROVE

Gilad Kaufman, PhD,
Tofurky

Haibo Huang, PhD,
Professor, Virginia Tech

Henk Hoogenkamp PhD,
Food for Thought Holding B.V.

Izabela Gladkowska, PhD,
Science and R&D Lead, Samyang Foods R&D Center Europe

Jay Karandikar

Jeffray Behr,
NSTX Industries (New School Foods)

Kanagaraj C S,
seruta corp

Karen McDonald, PhD,
University of California Davis

Karla Parker,
Kalsec

Karsten Schellhas,
Schellhas Food Technology

Kashif Khan,
Principal, KCS LLC (Consulting Services Company)

Kathleen Alexander, PhD,
Savor

Kristin Soave,
Innovation Platform Leader, Kalsec

Mehmet Caglar Tulbek, PhD,
President, Saskatchewan Food Industry Development Centre

Sruthi Sadanand,
Founder & CEO of Altruistic Innovations

v2foods Pty Ltd.

Vince Charbonneau,
NSTX Industries (New School Foods)

Zagorka Blazevska, PhD,
Food Innovation & Nutrition Expert, General Manager, VITA NOVA-ZA d.o.o.

GFI's approach to rigorous analysis

GFI's Science and Technology Department publishes primary research and analysis to inform timely decisions related to alternative protein technology and innovation. We use a structured, evidence-based process to ensure our analyses are grounded in the best available science and practice, apply rigorous methods, and are transparent and open to scrutiny. This process is not a substitute for independent peer review; rather, it provides a rigorous and practical approach to producing high-quality analysis in areas where evidence and technologies are rapidly evolving.

Our structured process includes:

Use of the best available data: We prioritize authoritative open-access data, primary data, and peer-reviewed literature representing real-world conditions. Where these sources are unavailable, we supplement with confidential industry data, modeled data, and expert input.

Validation with external experts: We consult scientists, consultants, investors, economists, and practitioners across industry, government, and academia to test assumptions and fill gaps in data. Expert input informs our analysis but does not constitute endorsement of our findings.

Review of methods, assumptions, and findings: GFI scientists outside the authoring team and colleagues across relevant programmatic teams review every analysis. Reviewers examine methods, calculations, assumptions, and the fit between evidence and claims, and are asked to challenge findings regardless of whether they support GFI's mission.

Transparency around uncertainty and limitations: Where the underlying data do not support precision, we report ranges rather than point estimates. Reports include an assumptions and limitations table highlighting key uncertainties and conditions that may affect interpretation.

Transparency of data and results: Where feasible and permissible, we make datasets, models, and calculation workbooks available as supplements to the primary report.

Openness to feedback: Report webpages provide a mechanism for readers to submit substantive methodological feedback or potential errors.

Technical independence and funding: GFI is a nonprofit funded by philanthropic donations. Funders do not review or approve findings before publication. Relevant conflicts of interest are disclosed. For more information, see https://gfi.org/resource/how-we-are-funded/.

Table of contents

Authors 2

Acknowledgments 2

GFI's approach to rigorous analysis 4

Executive summary 6

What we learned 6

Why this matters 6

Main takeaway 10

Key recommendations 11

Introduction 15

The plant-based meat industry today 16

Techno-economic analysis design 18

Current plant-based meat production costs 22

Production costs are up to 2x higher than conventional meat 22

Ingredients, especially flavors, are the primary cost driver 23

Current low-demand pathways to lower production costs 25

Ingredient selection is critical to near-term cost reduction 26

Operational efficiency improvements reduce near-term COGS 28

Contract manufacturing can lower COGS, but only with favorable fees 29

Production location can significantly affect costs: Regional case studies 30

Future high-demand plant-based meat production costs 31

Future-state ingredient pathways to lower production costs 33

Price ceiling targets for ingredient innovation 36

Extrudate costs are driven by raw materials and CMO usage 39

Capital intensity is not a primary cost barrier 42

Moderate scale up delivers capital efficiency gains 42

Plant-based and conventional meat have similar capital efficiency 44

Calls to action 46

References 47

Regional case studies 48

Appendix 53

Key assumptions and limitations 53

Expanded methods 56

Post-production costs — detailed findings from interviews 57

Executive summary

What we learned

Plant-based meat production costs remain above conventional meat targets, primarily because of formulation costs and manufacturing inefficiencies. In the near term, some products can reach cost parity without increased demand. In the long term, ingredient innovation must deliver better sensory performance at competitive cost to drive demand and enable the scale needed to close the remaining gap for a wide range of products.

This analysis explores the cost drivers of plant-based meat production and evaluates viable pathways to improve cost competitiveness today and in the future.

Why this matters

Plant-based meat can help meet the world's growing demand for meat while increasing food security, promoting biodiversity, and protecting public and planetary health. Realizing these benefits, however, requires products that can compete with conventional meat on the attributes consumers value most: taste and price.

Today, many plant-based meat products fall short on both fronts. Despite using less energy and fewer raw materials than conventional meat production, plant-based meat remains significantly more expensive. In 2025, in the United States, most plant-based meat categories averaged two to four times the price of their conventional counterparts on a per-pound basis. Further innovation is also needed to deliver the sensory experience consumers expect from meat.

Key findings

1 The current gap: Production costs are up to 2x higher than conventional meat.

Modeled production costs (represented by cost of goods sold, or COGS) for plant-based meat under current-state conditions are ~25–100% higher than conventional meat targets (Table 1). This cost gap is not uniform across products, for example, ground beef cost is relatively close to parity, while whole-cut chicken COGS is more than double the parity target (Table 1).

Table 1. Modeled cost of goods sold (COGS) for plant-based meat products under current production conditions compared to conventional meat cost targets. Conventional meat cost targets reflect the mainstream/standard segment of the benchmark products and are estimated from U.S. retail and wholesale prices minus post-production markups and costs.

$/kg	Ground beef	Chicken nuggets	Whole-cut chicken
Current plant-based COGS	$6.52	$6.20	$7.36
Conventional meat COGS parity target	$5.26	$3.77	$3.63
% difference	+24% above parity	+65% above parity	+103% above parity

2 Ingredients and manufacturing inefficiency drive the current cost gap.

A. Low market share and inconsistent demand lead to manufacturing inefficiencies.

- Interviews with 40+ companies and experts indicate that owned plant-based meat manufacturing facilities are relatively small-scale (5,000 metric tonnes per year (MTA) or less), and utilize only ~50% of available capacity on average, with product losses of up to 20%.
- Experts attribute these manufacturing inefficiencies to low and inconsistent demand, which contributes to shorter production runs, frequent changeovers, and underutilized capacity (Figure 1).
- Additionally, these conditions can lead to overreliance on contract manufacturing organizations (CMOs), which—particularly when CMOs charge fees over $2.00/kg of finished product—may increase costs.

B. Ingredients are the largest cost driver.

- Plant-based meat formulations often require specialty flavors, binders, and colors that are relatively expensive. This contributes to high ingredient costs, which account for over half (55–62%) of the modeled production cost.
- Flavor ingredients alone account for 33–39%, driven by specialty flavors, which are particularly cost-intensive, averaging ~$40–60/kg, because they are often customized for specific products.

C. Capital efficiency is not a major constraint.

- Extrudate and finished-product facilities quickly achieve economies of scale even with moderate scale up because they use optimized, well-established, commercial-scale equipment and production systems.
- Plant-based meat requires similar capital investment per unit of capacity as conventional meat, suggesting limited need for further capital-cost reductions.

Low demand creates a negative feedback loop that increases costs and constrains consumer adoption.

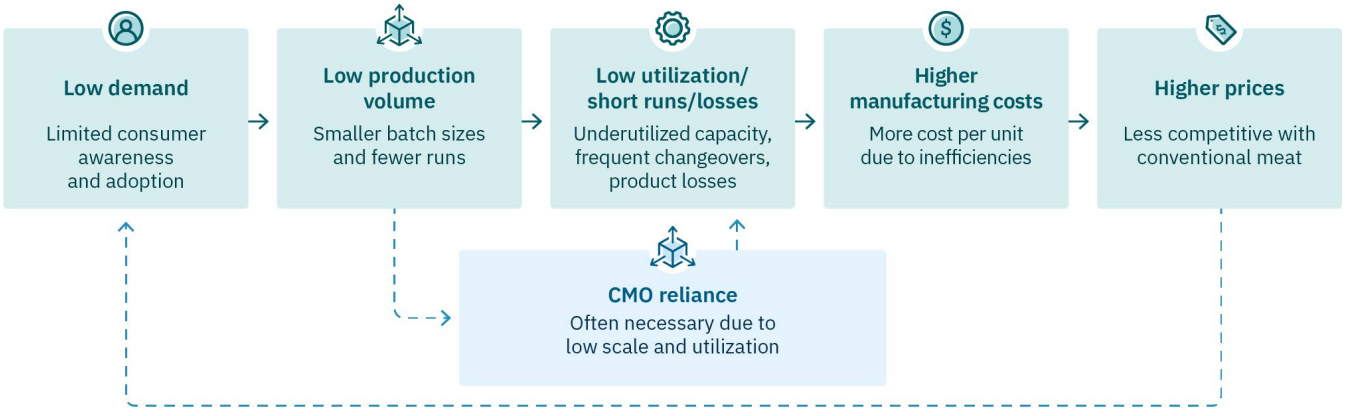


Figure 1. The negative feedback loop of plant-based meat production and cost.

3 Pathways to parity exist today without added demand.

Under weak demand conditions, several strategies exist to achieve parity for ground beef and chicken nuggets that do not depend on increased consumer demand (Figure 2). For ground beef, any one of the strategies below is sufficient to achieve or approach parity, but multiple strategies are needed for chicken nuggets.

A. Improve operational efficiency of owned manufacturing without added capital investment.

- Increasing utilization (from 50% to 100%) of the current-state small-scale facility and reducing product loss (from 20% to 10%) resulted in a ~$1.00/kg reduction in modeled COGS for ground beef and chicken nuggets, bringing ground beef within range of its parity target.
- Increased utilization and reduced product loss can be achieved by:
  - Centralizing production in fewer facilities,
  - Contracting excess capacity to other producers with similar production requirements, and
  - Optimizing production schedules.

B. Reduce formulation costs through lower-priced flavors and extrudates.

- Using specialty flavor and extrudate ingredients currently available at the low end of today's prices reduced COGS by ~$2.00/kg, achieving parity for ground beef.
- Low ingredient costs require deliberate formulation and supplier choices, with sensory trade-offs that may dictate product formats and sales channels.

C. Use CMOs with favorable fees.

- Modeled COGS for ground beef and chicken nuggets decreased by ~$1.80/kg when manufacturing was shifted from an underutilized, high-product-loss owned facility to a CMO with favorable fees.
- Use of a low-cost CMO (conversion fees below ~$2.00/kg of finished product) can help achieve cost parity for ground beef and chicken nuggets.

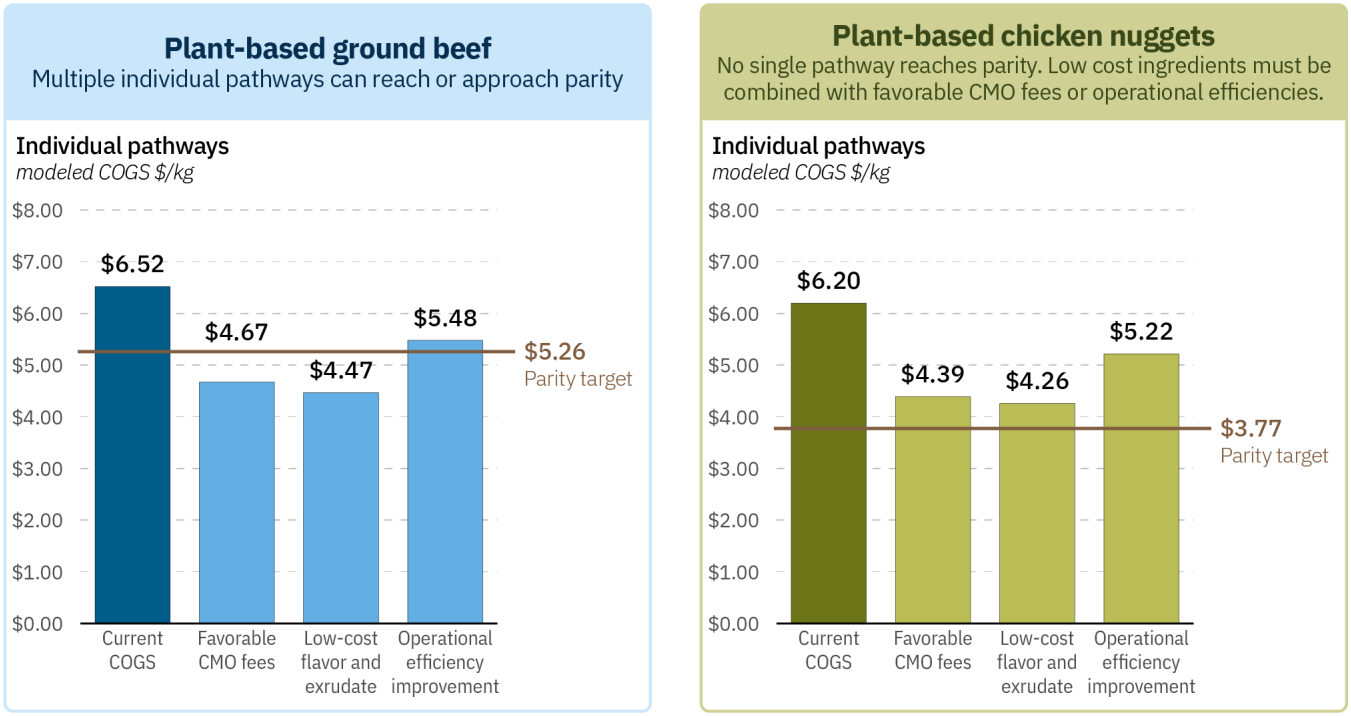


Figure 2. Pathways to achieve or approach parity today for ground beef and chicken nuggets. Favorable CMO fees = $1.32/kg final product; Operational efficiency improvement = 100% utilization (82% uptime) and 10% product loss; Low-cost flavor system (specialty flavors + spices and yeast) = $8.91/kg; Low-cost extrudate = $1.50/kg.

4 Breaking the cost-demand cycle in the long term will require ingredient innovation and scale.

To drive broader consumer adoption, plant-based meat needs to deliver improved sensory performance without increasing formulation costs. Increased and more consistent demand can then enable larger-scale, higher-utilization manufacturing, further reducing production costs. Together, lower-cost, higher-performing ingredients and scaled manufacturing can bring all three modeled products below conventional meat cost targets (Table 2).

A. Ingredient innovation: Deliver better sensory performance with flavor and extrudate improvements at lower cost.

- Ingredient innovation is essential for both cost and taste parity and creates conditions for greater consumer demand.
- Concentrating research on the highest-impact protein, flavor, and fat challenges while aligning with the cost targets defined in this analysis can focus development on solutions with the greatest potential to accelerate parity.

▸ See Key recommendations section for specific innovation recommendations.

B. Scaling: Increase facility production volume and operational efficiency

- More consistent and greater consumer demand breaks the negative feedback loop (Figure 1) and allows for larger-scale facilities with high operational efficiency (high facility utilization + low product loss).
- When modeled together, scale and operational efficiency reduce the cost gap by 29–38% compared to the modeled current production scenario (holding other input costs constant).

Combined with flavor, fat, and protein prices at the low end of modeled ranges, scale and operational improvements bring all modeled products below parity targets (Table 2).

Table 2. Future COGS + low protein, flavor, and fat ingredient pricing. Future COGS represents a 15,000 MTA facility at 100% utilization (82% uptime) and 10% product loss. Low protein, flavor, and fat ingredient pricing represents the low end of 2026 ingredient prices.

$/kg	Ground beef	Chicken nuggets	Whole-cut chicken
Future COGS + low ingredient pricing	$2.97	$2.84	$3.01
COGS parity target	$5.26	$3.77	$3.63
% difference	**44% below parity**	**25% below parity**	**17% below parity**

Main takeaway

Plant-based meat production costs remain above conventional meat targets, primarily because of formulation costs and manufacturing inefficiencies. Ground beef and chicken nuggets can reach cost parity today without increased demand through improved operational efficiency, lower-cost formulations, and/or favorable CMO economics (Table 3). In the long term, ingredient innovation must deliver better sensory performance at competitive cost, helping drive demand and enable the scale needed to close the remaining gap for whole-cut chicken and create a more mature and stable manufacturing supply chain.

Table 3. Summary of scenarios where products achieved conventional meat cost target.

	Ground beef	Chicken nuggets	Whole-cut chicken
Current "low-demand" manufacturing	✗	✗	✗
Current + near-term cost reduction strategies	✓	–	✗
Future ingredient innovation + scale-up with higher demand	✓	✓	✓

✗ = did not achieve target; ✓ = achieved target with a single strategy applied; – = achieved target with multiple strategies applied. Current conditions = low-demand environment resulting in manufacturing inefficiencies and small-scale facilities. Future conditions = high-demand environment with larger-scale facilities, high manufacturing efficiency, and cost-competitive ingredients.



Photo credit: Impossible Foods

Key recommendations

Plant-based meat manufacturers and supply chain partners

Actionable pathways exist to reduce costs and accelerate the path to price parity, even without increased demand. Targeted formulation and manufacturing efficiency improvements can deliver meaningful near-term savings, with greater reductions possible as the market scales.

Use low-cost CMOs where quality can be maintained.	Expert interviews and modeling indicate CMO tolling fees range from ~$1.32–5.00/kg. For plant-based ground beef, fees at the lower end of this range can significantly reduce COGS relative to production in current-day owned facilities, bringing costs below parity targets. Manufacturers should weigh these savings against potential trade-offs in production quality control and reliability.
Generate value from idle capacity by contracting production for similar products.	Manufacturers with excess capacity could contract production for plant-based products with similar processing requirements, increasing utilization and enabling longer production runs while minimizing changeovers and product losses.
Reduce formulation costs by testing lower-cost extrudates and flavor systems.	Lowering flavor and extrudate costs was the single most effective way to significantly reduce COGS across products. Selecting ingredients at the low end of their price ranges ($10/kg for specialty flavor and $1.50/kg for extrudate) significantly reduced COGS. Managing trade-offs in sensory performance can be achieved by choosing appropriate formats, sales channels, or complementary ingredients such as spices and sauces.
Co-manufacture with legacy producers using existing facility production lines.	Leveraging existing producer infrastructure avoids capital-intensive builds, though allergen isolation and dedicated runs remain crucial for product integrity.



Photo credit: Carlos Gonzales/Stocksy/Adobe Stock

Researchers and ingredient developers

Ingredient innovation is essential for both cost and taste parity. Concentrating research on the highest-impact protein, flavor, and fat challenges paired with specific cost-in-use targets can focus development on solutions with the greatest potential to accelerate parity.

Advance protein solutions to improve flavor neutrality and enable greater use of less-refined ingredients.	Crop breeding and improved ingredient processing can produce protein inputs with fewer off-notes and reduce the need for masking agents and complex flavor systems, freeing up formulation budget while also making it easier to achieve the desired sensory profile. Improving the texturization and sensory performance of less-refined inputs, such as dry-fractionated protein concentrates and protein flours, can further reduce protein ingredient costs.
Design multifunctional hybrid and blended ingredients that replace existing cost drivers.	Fermentation-derived, cultivated, and animal-derived fats, proteins, and flavor ingredients can improve sensory performance while replacing multiple existing formulation components, potentially offsetting their higher cost. Researchers should design these systems around the maximum cost-in-use the finished product can support, considering both inclusion rate and the costs of the ingredients they displace. The report's ingredient price ceilings provide concrete R&D targets for balancing performance, inclusion rate, ingredient displacement, and price.
Enable larger-scale production and distribution of high-moisture extrudate (HME) ingredients.	Develop more standardized HME formats and stronger demand signals across the industry to aggregate purchasing volumes and make ingredient-supplier-led HME production more commercially viable.
Develop cost-effective flavor systems and solid fat alternatives to tropical oils.	Design flavor and structured fat technologies around finished-product cost-in-use targets and assess economic feasibility early in development. Prioritize solutions that can meet ingredient price ceilings at scale or replace other costly ingredients.



Photo credit: C. Arcurs/peopleimages.com/Adobe Stock

Investors and capital providers

Plant-based meat offers low technical execution risk and high capital efficiency. Targeted investments in near-term production improvements can deliver significant cost reductions, improve unit economics, and increase product competitiveness.

Invest in cost-effective ingredient innovation, with a focus on flavor.	Prioritize technologies that can meet the ingredient price ceilings required for finished-product cost parity or that replace other costly ingredients in the formulation. Flavor is particularly constrained: at baseline prices for other ingredients, flavor must remain below approximately $51/kg for ground beef, $25/kg for chicken nuggets, and $20/kg for whole-cut chicken to maintain parity.
Invest in companies scaling sensory-enhanced HME.	Few U.S. ingredient suppliers currently produce HME, forcing plant-based meat manufacturers to rely on CMOs or build their own capacity. Co-producing low moisture extrudate (LME) and HME at commercial scale can substantially reduce HME costs while maintaining similar LME production costs. Importantly, sensory-enhancing HME technologies (e.g., gas injection) can be integrated into commercial extrusion with relatively modest additional capital investment.
Prioritize operational enablers like shared infrastructure models and yield-optimizing technologies.	Fund low-cost (≤$2.00/kg final product) CMO or shared manufacturing models and processing automation technologies. Aggregating volume to achieve full facility utilization is the most powerful operational lever for cost reduction. Pairing higher utilization with loss-reducing technologies drives compounding savings across fixed overhead and raw material costs.



Photo credit: marqs/Adobe Stock

Policymakers

Plant-based food manufacturing facilities can create high-quality jobs and access new markets for regional crop inputs such as soy, corn, wheat, and specialty crops. Plant-based foods have important production efficiency, shelf-stability, and sustainability benefits, making them more resilient against food supply shocks. Investment in plant-based food manufacturing is investment in food security, resource efficiency, public health, and economic development.

Establish or expand loan, loan guarantee, tax incentive, and grant programs to support efficient commercial-scale manufacturing.	Loan and loan guarantee programs can de-risk and crowd in private capital to finance plant-based manufacturing facilities at low cost to the government. Tax incentives and grants can reduce the capital burden on companies, allowing them to build and scale sooner and manage the ramp toward higher facility utilization. GFI interviews with industry stakeholders indicate that where companies choose to build facilities greatly depends on the public incentives available. Policymakers who establish and expand programs that support manufacturing scale up will successfully attract business to their jurisdictions.
Fund open-access research to optimize ingredients for flavor.	Funding R&D for crop development, ingredient optimization, flavor enhancement, and product formulation will improve the taste and lower the cost of plant-based meat and de-duplicate research currently occurring within private companies. Establishing an AI-enabled national data repository for food biotechnology would improve ingredient discovery and optimization.
Support shared infrastructure.	Shared pilot-, demonstration-, and commercial-scale infrastructure can allow food companies to test, develop, and produce products without outlaying large amounts of capital to build facilities. By aggregating fragmented production across multiple facilities, shared infrastructure can improve facility utilization and reduce capital burden. Governments should fund and incentivize shared facilities, which can also function as workforce development hubs.

Introduction

Plant-based meat has the potential to help satisfy the world's growing demand for meat while increasing food security, promoting biodiversity, and protecting public and planetary health. To deliver these benefits, products must compete with conventional meat on the attributes that matter most to consumers. Across global markets, consumer research consistently shows that taste and affordability are the primary drivers of purchasing decisions. While health, sustainability, and animal welfare are important differentiators for plant-based meat and can influence consumer interest, sustained, repeated purchasing depends on plant-based meat matching conventional meat on taste and price.

Multiple studies across North and South America, Europe, and parts of Asia support this conclusion. In the United States, consumers who have tried plant-based meat but stopped eating it are most likely to cite taste, texture, and high prices as reasons for leaving the category, while improvements in these attributes are the strongest motivators for future purchase. Across Asia-Pacific markets, affordability is the single most important factor influencing plant-based meat consumption, with purchase intent increasing when products reach price parity with conventional meat and rising further as prices drop below parity. Similar findings have been reported in Europe, where price has emerged as the most prominent reason consumers do not choose plant-based alternatives. Likewise, in Brazil, high prices, difficulty finding the products, and taste are the top three barriers to purchasing plant-based alternatives.

These findings suggest that taste and price are prerequisites for mainstream adoption.

However, setting aside taste parity, plant-based meat remains far from price parity with conventional meat. In 2025, most plant-based meat categories averaged two to four times higher than their conventional counterparts on a per-pound basis in the U.S.* These consumer prices are heavily influenced by manufacturing economics. While business strategy, supply chain markups, and market dynamics also contribute to final consumer *prices*, reducing production *costs* is a necessary and durable pathway toward improving affordability. Understanding current and potential manufacturing costs, cost drivers, and opportunities for cost reduction is therefore critical. A techno-economic analysis (TEA) provides a systematic framework for addressing these questions by modeling production costs and evaluating the impacts of technological and operational improvements.

Few publicly available TEAs have examined the cost of producing plant-based meat products or their primary protein inputs such as soy, pea, and other pulses.[1–6] These studies vary considerably in their system boundaries and the maturity of the production systems considered, limiting their comparability and applicability to current-day plant-based meat products. Recent industry research has also examined the barriers and paths to parity through broader market analysis rather than techno-economic modeling.[7] An important opportunity therefore remains to model the cost drivers of plant-based meat products on the market today.

To help address this gap, GFI, in partnership with Next Rung Technology, conducted a comprehensive TEA of plant-based meat production. As part of the study, GFI interviewed over 40 experts, companies, and organizations across the value chain and obtained price quotes from major ingredient and equipment suppliers to validate the model's cost inputs and ensure the TEA reflects today's costs and industry realities.

* For an up-to-date look at the price gap, see GFI's U.S. retail market insights page.

The study addresses the following research questions:

1. What is the cost of production given the way plant-based meat is primarily made today?
2. What are the cost drivers of plant-based meat production today?
3. What are the pathways to reduce the cost of production of plant-based meat?
4. What is the target cost-in-use for specialty ingredients and processes outside the primary protein ingredient, such as flavors, fats, and colors?

By providing a transparent, engineering-based assessment of production costs based on real-world industry data, this study establishes an economic benchmark of where the industry is today and feasible pathways to reach price parity in the future.

The findings are intended to inform cost-reducing R&D, investment, policymaking, and collaborations by identifying the cost drivers and innovation opportunities with the greatest potential to reduce costs.

This report summarizes the key findings and recommendations for the TEA, with the full technical report available here.

The plant-based meat industry today

Scale and supply chain

Industry discussions conducted for this study consistently identified scale and operational efficiency as central cost constraints, noting that the plant-based meat sector still operates at relatively small volumes and lower efficiency than more established food manufacturing sectors due to its market size and early stage of development. A challenging plant-based meat sales environment constrains production volumes, leading to fewer and smaller brand-owned facilities and shorter production runs. Additionally, many manufacturers produce multiple products at the same facility to meet a variety of consumer preferences. These conditions contribute to lower plant utilization, more frequent changeovers, higher product loss, and a greater reliance on contract manufacturing organizations (CMOs). Together, these factors create a fragmented, lower-volume supply chain that reinforces the industry's cost challenge (Figure 3).

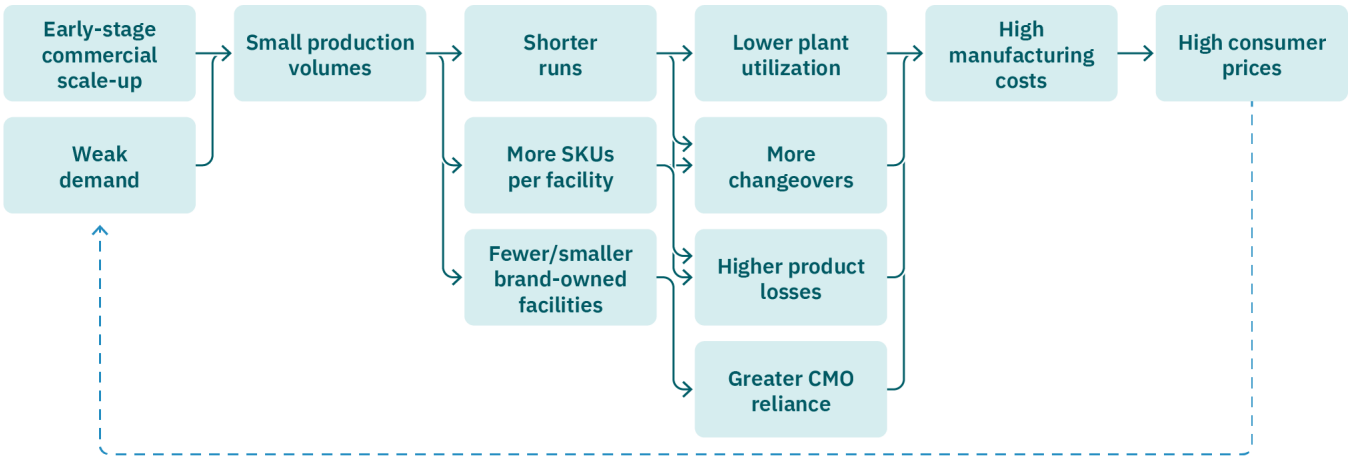


Figure 3: The self-reinforcing cycle of plant-based meat production. The lack of category-wide sales growth limits scale and operational efficiency; limited scale raises costs, and higher costs further constrain consumer adoption. SKU refers to a stock-keeping unit, i.e., an individually sold product or product variant.

Table 4 summarizes the key operational characteristics used to distinguish current plant-based meat production from a more mature, high-volume manufacturing environment. These characteristics represent broad industry conditions that affect production economics, including annual production volume, facility utilization, product loss, and reliance on CMOs.

Table 4: Current vs. optimized production

	Current production	Optimized production
Production volume	500-5,000 MTA	15,000-100,000 MTA
Plant utilization*	50%	100%
Product loss	15–25%	<10%
CMO usage	High, multiple may be used	Few or none

*Plant utilization is defined as the actual operating time as a percentage of the total available operating time, which accounts for holidays and scheduled downtime. 100% plant utilization = 82% plant uptime.

Post-production costs

After a product leaves the factory gate, post-production costs frequently combine to push final prices to more than double the cost of goods sold (COGS) regardless of scale or manufacturing efficiency. Interviews with more than 40 companies, investors, and researchers provided directional insight into the markups that drive the gap between production cost and price. Estimates of brand markups (~20%), distributor fees (10–50%), broker commissions (5%), and retail and foodservice margins (30–40%) provide a window into the cost ladder from COGS to end-product prices. A full analysis of post-production costs was beyond the scope of this study, but we have included a limited additional discussion in the Appendix.

GFI Europe and Arthur D. Little plan to publish a more detailed analysis of post-production costs building on this TEA in February 2027.



Photo credit: Various Dishwill Co., Ltd.

Techno-economic analysis design

This study models the production of three plant-based meat products: ground beef, chicken nuggets, and whole-cut chicken. These formats were selected based on strong consumer sensory testing performance, comparatively high market share, and to span a range of manufacturing complexity.[8] The model includes extrusion, downstream processing, and final packaging. Upstream ingredient production is outside the system boundary. Instead, ingredient prices are treated as model inputs, reflecting how manufacturers procure ingredients. Downstream distribution, retail, and other post-production activities are also excluded due to uncertainty in the absolute contribution of post-production costs. Overall, this analysis focuses on the technical components that most directly inform the cost of production.

Within this boundary, we modeled two separate facilities under hypothetical current and future scenarios: a large extrusion facility representative of a major ingredient supplier, and a smaller finished-product facility meant to represent a separate plant-based meat manufacturer. Key assumptions vary between the current and future scenarios, with the current scenario reflecting lower-volume, less-optimized production and the future scenario representing higher-volume, more optimized production based on the ranges summarized in Table 4.

Based on industry interviews, this analysis models low-moisture soy-based extrudate produced at large scale for both current and future scenarios. In the current scenario, a brand-contracted CMO produces high-moisture extrudate; in the future scenario, the large extrusion facility produces it. In both cases, the plant-based meat manufacturer purchases the extrudate. For more discussion on this topic, please see Why does the model use purchased, soy-based extrudate?

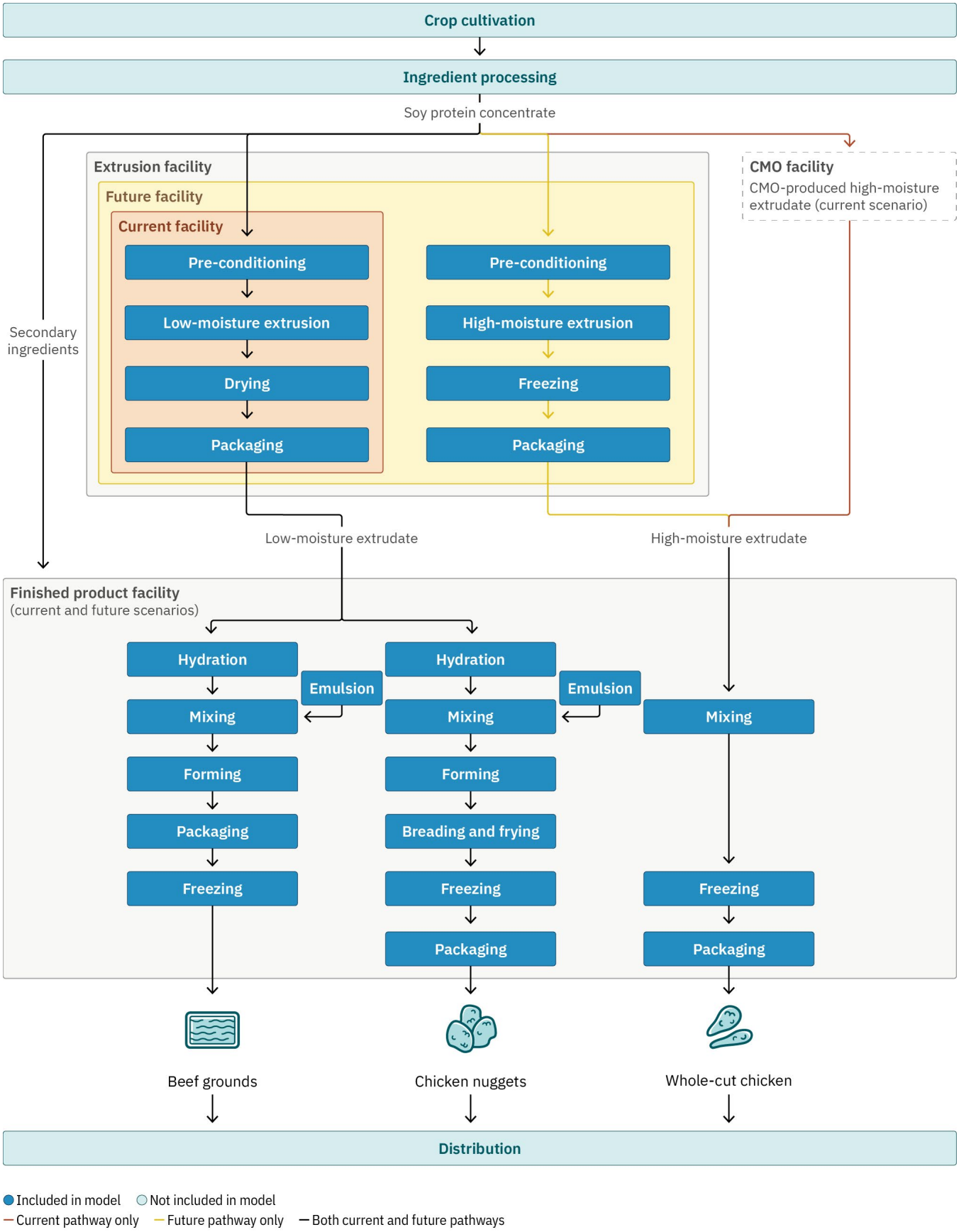


Figure 4: Modeled system boundary and summarized process flows for this techno-economic analysis.

Each product follows a production pathway that reflects its formulation and processing requirements through these facilities, shown in Figure 4. Soy protein concentrate is combined with water and texturized by extrusion to form a structured protein base or extrudate. The finished-product facility procures the extrudate and secondary ingredients, combines them to form the final product formats, and packages them for retail sale.

Table 5 summarizes the ingredients used in the three modeled products. All products use extruded soy protein as the primary ingredient. Ground beef and chicken nuggets are modeled using purchased low-moisture extrudate (LME), while whole-cut chicken pieces are modeled using high-moisture extrudate (HME). The products include a common set of secondary ingredients: flavors, colors, spices, micronutrients, preservatives, and a liquid fat.

Product-specific ingredients are included where relevant, including binders and solid fat for ground beef, and binders, breading, fry oil, and a secondary protein source for chicken nuggets. Secondary ingredients are included according to product requirements and data availability. For a complete list o f ingredients and their relative amounts in each formulation, please see the Data workbook.

The analysis models facilities in the U.S. Midwest, reflecting the region's relevance to U.S. food manufacturing, agricultural input supply chains, and available cost data. The analysis also includes current-state regional case studies for Brazil and India to evaluate how production economics vary across geographies. Additional detail on this study's methods, assumptions, and limitations is provided in the Appendix.

Table 5: Ingredient summary of modeled products.

<table>
<tr><th></th><th>Primary protein ingredient</th><th>Secondary ingredients</th><th>Distinct Secondary Ingredients</th></tr>
<tr><td>Ground beef</td><td rowspan="2">Low-moisture extrudate of soy protein concentrate</td><td rowspan="3">Flavors, colors, spices, micronutrients, preservatives, liquid fat</td><td>Binders, solid fat</td></tr>
<tr><td>Chicken nuggets</td><td>Binders, breading, frying oil, secondary protein source</td></tr>
<tr><td>Chicken pieces</td><td>High-moisture extrudate of soy protein concentrate</td><td></td></tr>
</table>

Why does the model use purchased, soy-based extrudate?

Textured soy protein remains the industry staple for plant-based meat. Across interviews, stakeholders emphasized that extruded soy protein is the most widely used across the industry because it offers a currently unmatched combination of cost, availability, functionality, and predictable behavior at commercial scale.

Interviewees noted that textured soy provides a reliable fibrous structure at a significantly lower cost than pea, which is another widely used protein in many plant-based meat applications. Pea was often described as brittle and as having beany off-notes that require expensive flavor masking. Wheat gluten is also widely available, commoditized, and highly functional, but it is more commonly used as a complementary ingredient than as a primary protein base. Other protein sources such as fava were identified as promising but not yet commercially ready to replace soy at similar cost, scale, availability, or functionality.

The model also reflects current industry practice of purchasing extrudates from external suppliers rather than manufacturing in-house. Interviewees noted that plant-based meat brands most often purchase LME from external suppliers. While this separation can add freight, handling, and supplier markups, interviewees generally did not view in-house extrusion as advantageous, particularly for LME, given its commoditized supply, shelf stability, and low shipping weight.

The model treats HME differently because it is not yet widely available from major suppliers. Brands more often described producing HME at CMOs, even with proprietary processes and formulations, suggesting that even specialized extrusion does not always justify bringing production in-house.



Photo credit: Rebellyous Foods

Current plant-based meat production costs

The current-state assumptions reflect the operating conditions that many plant-based meat manufacturers face today: small production volumes, low facility utilization, high product loss, short production runs, and continued reliance on contract manufacturing. For extrusion, the current production scenario assumes that a large ingredient manufacturer supplies LME, while a brand-contracted CMO produces HME for whole-cut chicken.

Production costs are up to 2x higher than conventional meat

Under these conditions, the costs of producing plant-based ground beef, chicken nuggets, and whole-cut chicken, captured as COGS per kilogram, are $6.52 per kilogram, $6.20 per kilogram, and $7.36 per kilogram, respectively (Table 6). Overall, today's production costs range from 25% to 103% more than the conventional parity target.

Table 6: Model assumptions and COGS summary for current-state production. Results are shown in $/kg.

		Ground beef	Chicken nugget	Whole-cut chicken
Extrudate assumptions	**Extrudate type**	LME		HME
	Source	Ingredient supplier		Brand-contracted CMO
Extrusion facility assumptions	**Production volume**	50,000 MTA		
	Product split	100% LME		
	Plant utilization*	100%		
	Product loss	10%		
Finished product facility assumptions	**Production volume**	5,000 MTA		
	Product split	50% ground beef	30% chicken nugget	20% whole-cut chicken
	Plant utilization*	50%		
	Product loss	20%		
Current COGS summary	**Current COGS**	$6.52	$6.20	$7.36
	Parity target	$5.26	$3.77	$3.63
	Difference	**$1.26 above parity**	**$2.43 above parity**	**$3.73 above parity**

*Plant utilization of 100% represents 82% plant uptime, equivalent to 300 operating days per year and assumed to reflect the industry-standard maximum annual operating schedule.

Ingredients, especially flavors, are the primary cost driver.

Current costs are primarily driven by ingredients, which represent the largest share (55–62%) of COGS across products. Plant operating costs and labor (both 14–17%) are the next largest cost drivers, followed by equipment depreciation (8–10%). In comparison, utilities and transportation account for only a small fraction (0.2–1%) of overall COGS (Figure 5).

Ingredient costs for ground beef and chicken nuggets, produced with LME, are dominated by flavors, followed by extrudate, breading and frying ingredients for nuggets, and then binders and fats. Fortification, colors, and preservatives contribute only nominally. Whole-cut chicken ingredient costs are driven primarily by the high-moisture extrudate and flavors. Note that the LME price is modeled on available price data rather than estimated from the extrusion facility model (Table 7).

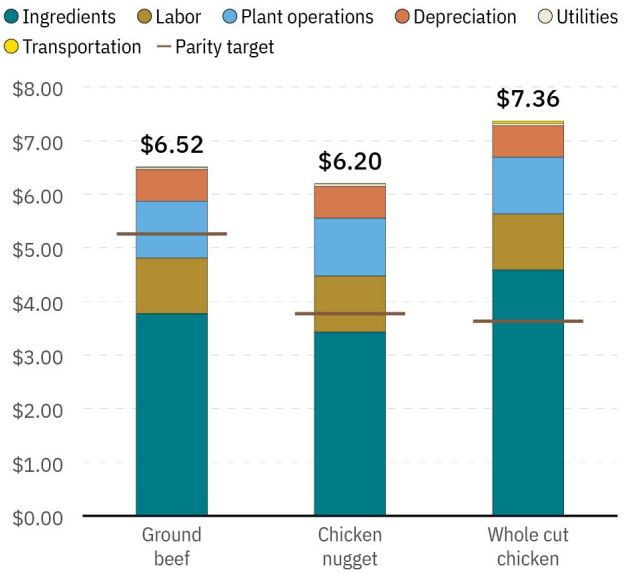


Figure 5: Under current conditions, cost of production is primarily driven by ingredients, followed by plant operations, labor, and equipment depreciation. Utilities and transportation costs are negligible in comparison.

For more discussion on the extrusion facility results, see the extrudate costs section or the full technical report.

Table 7: Unit price and cost-in-use for each formulation. Costs of ingredients vary across products. Ground beef and chicken nugget ingredient costs are dominated by flavors, while whole-cut chicken ingredient costs are dominated by both extrudate and flavors.

Ingredients		Ground beef		Chicken nugget		Whole-cut chicken	
Ingredients	Unit price ($/kg)	wt%	$/kg	wt%	$/kg	wt%	$/kg
Low-moisture extrudate	2.75	23.0%	0.79	16.0%	0.55		
High-moisture extrudate	2.54					73.0%	2.32
Secondary protein	1.50			1.0%	0.02		
Binders	15.00	1.5%	0.30	1.0%	0.19		
Liquid fats	1.50	7.0%	0.12	4.0%	0.07	3.0%	0.06
Structured fats	3.00	4.0%	0.15				
Flavors	37.09–38.97	4.5%	2.19	4.7%	2.20	4.8%	2.21
Colors	3.50–40.83	<1.0%	0.15	<1.0%	<0.01	<1.0%	<0.01
Preservatives & antioxidants	0.75–70.00	1.0%	0.07	<1.0%	0.02	<1.0%	<0.01
Vitamins & minerals	3.28–3.36	<1.0%	<0.01	<1.0%	<0.01	<1.0%	<0.01
Breading & frying ingredients	1.04			28.0%	0.38		
Total ingredients			**3.77**		**3.43**		**4.59**

After ingredients, plant operations and labor are the next largest cost drivers. Plant operation costs are driven largely by packaging materials and maintenance. The total operating expenses for the modeled current-state finished product facility are $15 M/year, of which packaging materials account for 10% as a whole (Figure 6).

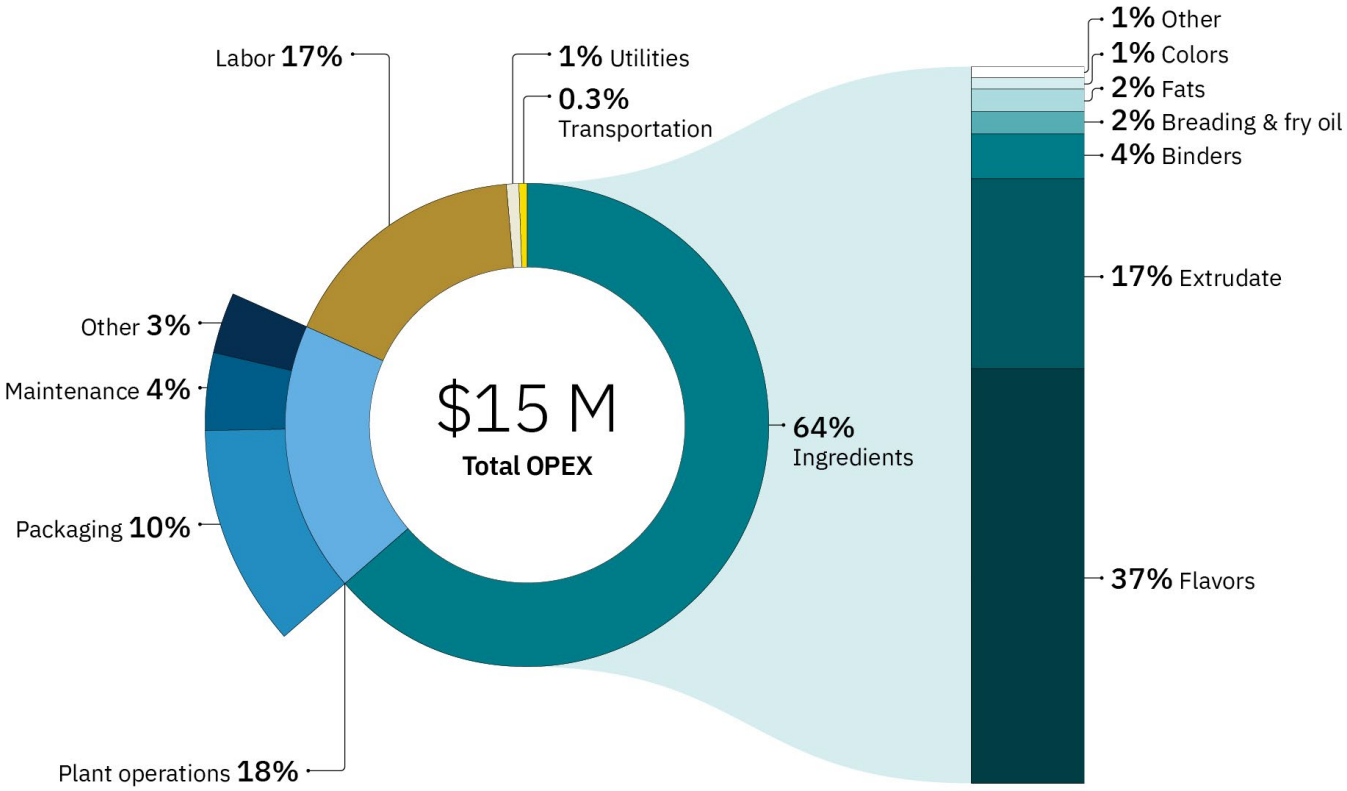


Figure 6: Current-state finished product annual OPEX, including all operating expenses for ground beef, chicken nugget, and whole-cut chicken production. Plant operation costs are driven largely by maintenance and packaging materials.

Current low-demand pathways to lower production costs

Multiple near-term pathways exist to bring both ground beef and chicken nuggets to parity. Ingredient cost and operational efficiency are the most important levers for near-term cost reduction, while outsourcing end-product formulation production to a CMO also presents an opportunity for cost reduction under favorable circumstances. Ground beef can reach parity through any one of these cost-reduction strategies, while chicken nuggets require lower formulation costs combined with either more efficient owned manufacturing or favorable CMO fees.

To identify these opportunities in today's industry context, we conducted a series of individual case studies to test how changes to key cost drivers affect total COGS. Increasing plant capacity is not a viable near-term lever before demand improves enough to justify increased production. Accordingly, this summary considers higher production volumes only in the future high-demand scenarios.

Table 8 summarizes the current low-demand case study assumptions, while Figure 7 summarizes the impact of these case studies across all three product formats.

Table 8: Current-state case studies conducted to identify cost reduction opportunities.

	Current-state assumption	Case study assumption	
Case study #1 Ingredient prices	Baseline prices	Low-end prices	
Case study #2 Plant utilization	50%	100%	*Combined into "Operational Efficiency Improvement"*
Case study #3 Product loss	20%	10%	
Case study #4 CMO usage	HME production	HME production Finished product production	
Case study #5 Plant location	U.S.	Brazil, India	

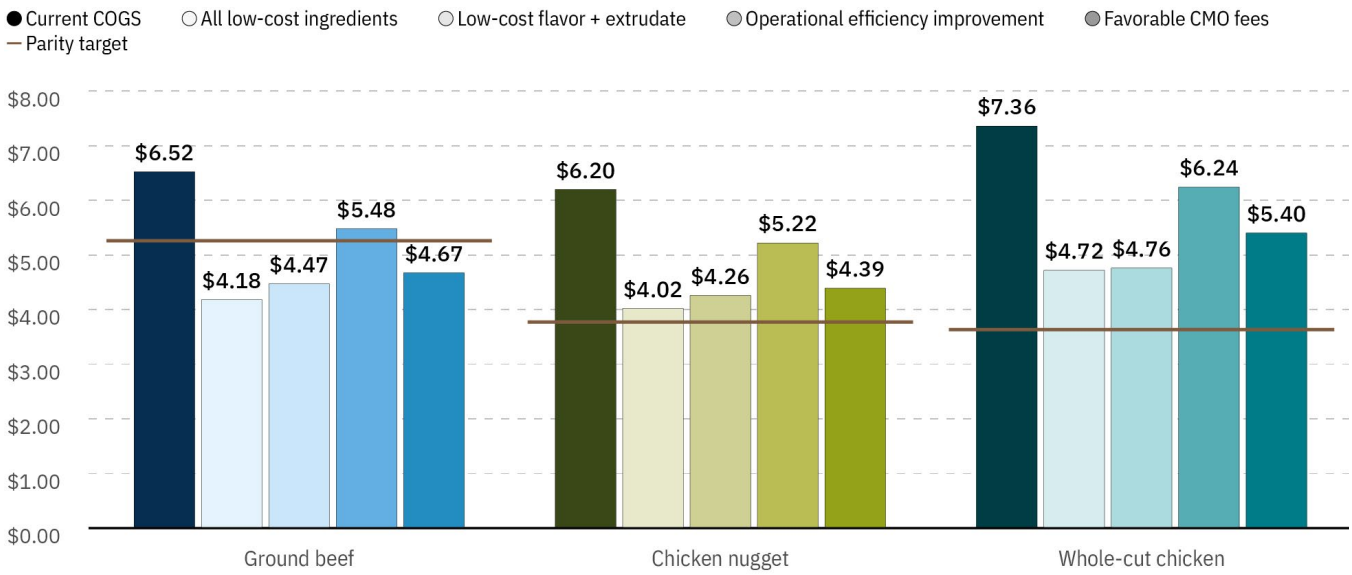


Figure 7: Summary of current low-demand cost reduction case studies.

Ingredient selection is critical to near-term cost reduction

Achieving parity requires careful ingredient selection and cost-in-use management, particularly for flavors and extrudate. Ingredient price inputs reflect 2024–2026 wholesale and international trade data, validated through expert interviews and supplier quotes. Baseline, low, and high pricing were derived from representative figures within each range. The model does not explicitly link prices to purchasing volume, though the ranges may capture some volume effects (Table 9).

While every ingredient priced at the low end of the modeled range would achieve a $2.39/kg COGS reduction on average, obtaining these prices simultaneously may be difficult, and the resulting formulation may fall short on sensory performance.

Among the ingredient categories modeled, lowering flavor costs had the largest effect, reducing COGS by approximately $1.70/kg across products. This reduction is primarily driven by liquid flavor—not spices or yeast extracts–because of its high baseline unit price and wide modeled price range. Extrudate price reductions have the next-largest impact, lowering costs by $0.36–0.91/kg, depending on the product. This range reflects differences in product formulation and extrudate sourcing, including the different cost structures of LME and HME. Together, reductions in flavor and extrudate prices lower COGS by $2.20 on average, accounting for 88% of ingredient-related cost savings for ground beef and chicken nuggets, and 99% for whole-cut chicken. Ingredient cost reductions bring ground beef below parity and chicken nuggets close to parity.

Table 9: Summary of ingredient price reduction case study.

Cost of Ingredients (Low vs. Base)

	Inclusion (wt%)	Examples	Ground beef		Chicken nugget		Whole-cut chicken	
			Low	Baseline	Low	Baseline	Low	Baseline
Extrudate	16.00–73.00%	LME, HME	$0.43	$0.79	$0.30	$0.55	$1.41	$2.32
Secondary protein	1.00%	Wheat gluten			$0.01	$0.02		
Binders	1.00–1.50%	Methylcellulose	$0.26	$0.36	$0.18	$0.24		
Liquid fats	1.00–3.00%	Canola oil	$0.03	$0.06	$0.01	$0.02	$0.03	$0.06
Structured fats	4.00%	Coconut oil	$0.05	$0.15				
Flavors	4.50–4.80%	Liquid flavor, yeast extract, spices	$0.50	$2.19	$0.51	$2.20	$0.51	$2.21
Colors	0.10–0.30%	Beet extract, paprika	$0.11	$0.15	<$0.01	<$0.01	<$0.01	<$0.01
Preservatives & antioxidants	0.02–1.00%	Vinegar, cultured dextrose, vitamin E	$0.06	$0.07	$0.02	$0.02	$0.00	$0.00
Vitamins & minerals	0.01%	B vitamins, zinc	<$0.01	<$0.01	<$0.01	<$0.01	<$0.01	<$0.01
Frying ingredients	28.00%	Wheat flour, starch, bicarbonate, oil			$0.22	$0.38		
Other operating costs			$2.75	$2.75	$2.77	$2.77	$2.77	$2.77
Total COGS ($/kg)			**$4.18**	**$6.52**	**$4.02**	**$6.20**	**$4.72**	**$7.36**
COGS Parity Target			$5.26		$3.77		$3.63	
Difference			**$1.08** Below parity		**$0.25** Above parity		**$1.09** Above parity	

However, ingredient cost reduction should be interpreted as a constrained lever rather than a simple procurement opportunity. Some inputs such as vitamins and minerals already have relatively limited impact on total COGS, while manufacturers have more strategic choice over higher-cost systems such as flavors and extrudate. Reaching the low end of the modeled ingredient ranges therefore requires deliberate product design choices and supplier selection, with trade-offs in sensory performance that may constrain viable product formats and sales channels. Manufacturers may also balance costs across ingredient systems, such as investing in a higher-quality extrudate while using a simpler flavor system, or incorporating spices and sauces to reduce reliance on liquid flavors. Products that use higher-cost flavor systems or extrudates may perform better with consumers, but they are more likely to remain above price parity and may need to target premium retail rather than mass-market parity. Conversely, products designed specifically for price parity will likely need to select lower-cost flavor and extrudate systems in the near term and target foodservice or private label channels.

Operational efficiency improvements reduce near-term COGS

Even without increasing production volume, operational efficiency improvements can meaningfully reduce COGS in the near term. Unlike a scenario in which all ingredients simultaneously fall to the low end of their modeled price ranges, efficiency gains may be more actionable in the near term through higher plant utilization and reduced product loss.

Figure 8 shows how facility efficiency improvements reduce COGS. Higher utilization allows the same equipment and facility to produce more product, reducing the per-kilogram burden of depreciation, materials and maintenance, labor, and cleaning. On the other hand, reducing product loss lowers COGS by improving yield. Because fewer inputs are lost during production, the total spent on ingredients is reduced.

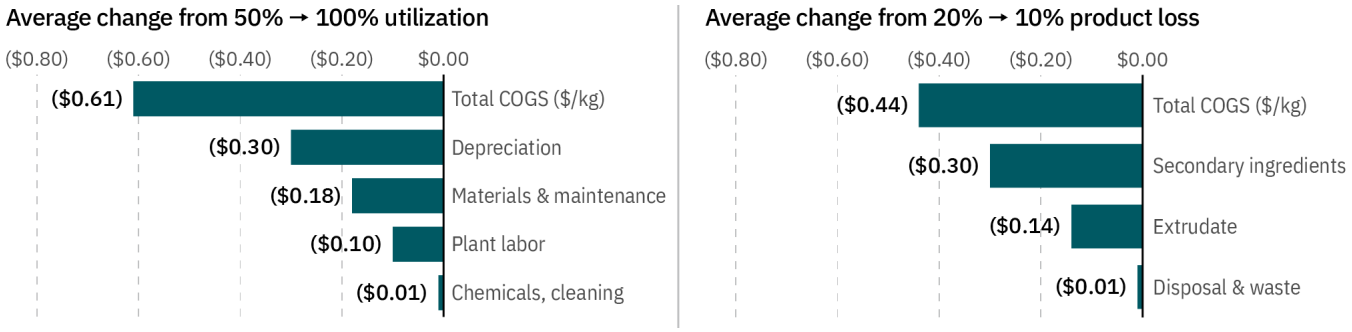


Figure 8: How utilization and product loss reduce COGS. Ingredient cost savings reflect improved yield rather than lower input prices.

TECHNOLOGY HIGHLIGHT:

Rebellyous's purpose-built manufacturing can improve plant-based chicken COGS

Rebellyous Foods is showing how manufacturing technology specifically designed for plant-based meat can help close the chicken parity gap, even under current market conditions.

The company's Mock 3 Production System replaces conventional batch processing with continuous, automated, just-in-time production. Rebellyous claims that the new system enables price parity in the highly cost-sensitive USDA National School Lunch Program.

Although this study did not independently evaluate these company-reported economics, they demonstrate how purpose-built processing equipment that increases throughput and reduces labor and other inefficiencies may enable cost outcomes beyond those represented by typical current-state production.

Contract manufacturing can lower COGS, but only with favorable fees

Outsourcing production to CMOs can bridge near-term scale and utilization challenges, but its cost competitiveness depends on negotiated tolling fees. In our modeling, CMO-based production can reduce COGS enough for some products to approach or reach parity when tolling fees are low, but it can also increase COGS substantially when fees are high (Figure 9). Based on expert interviews and modeled operating costs, fees for final-product manufacturing are estimated at $1.32–5.00/kg, although this range may not reflect lower-cost regions outside the United States. While these fees are shaped by production volume and product complexity, they are also business negotiations influenced by capacity, scheduling, customer relationships, margin expectations, and risk.

For a more detailed explanation of CMO fees and modeling, please see the Appendix.

At the low end of the fee range, CMO production reduces COGS by approximately $1.87/kg across products on average, bringing ground beef below its modeled parity target. At the high end, it increases COGS by $1.81/kg on average relative to an owned facility (Figure 9).

CMOs may therefore offer savings for higher-volume, lower-complexity products under favorable tolling conditions. Even when they do not enable parity, they can support short runs, pilot launches, demand validation, and production while demand grows enough to justify dedicated manufacturing. However, achieving parity through CMO production depends on negotiating favorable rates and may require trade-offs in ingredient pricing, sourcing, formulation, or product positioning.

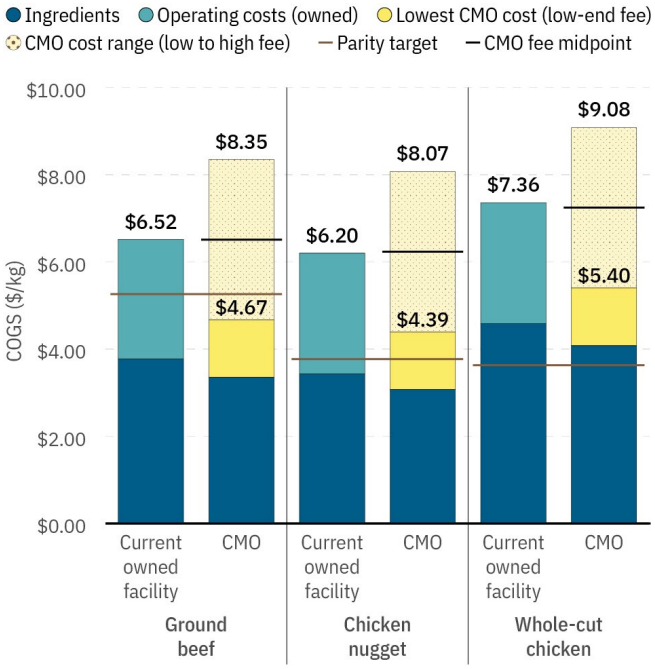


Figure 9: The range of possible CMO-produced COGS compared with current owned facility COGS. CMO fees are added to current ingredient costs adjusted for 10% product loss, assuming more efficient production at CMOs.

Production location can significantly affect costs: Regional case studies

Regional production can provide meaningful near-term COGS reductions where lower labor and capital costs reduce manufacturing costs. To evaluate this effect, we modeled current production in three regions: the U.S. Midwest (baseline), Brazil, and India, with the latter two selected as representative centers of growing demand. These case studies capture differences in region-specific construction, labor, and utilities. They compare current production economics across selected relevant markets rather than represent fully optimized regional production.

Compared with the United States, production in Brazil lowers COGS by an average of $0.90/kg across products, while production in India lowers COGS by an average of $1.31/kg (Figure 10).

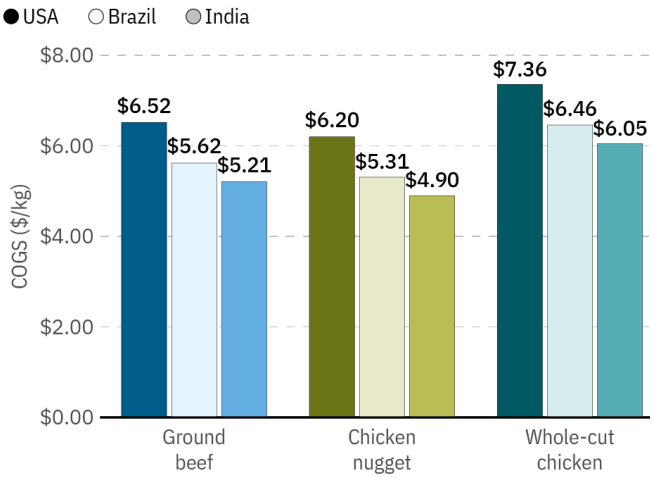


Figure 10: Current modeled COGS by region and product.

Regional savings are driven primarily by lower labor costs (Figure 11). Although lower than U.S. labor costs, these regional labor costs do not rely on below-minimum-wage assumptions. Indian wages exceed applicable state minimums, while Brazilian estimates incorporate official occupation-specific wages, statutory compensation and contributions, and employee benefits. After labor, the next-largest modeled savings come from lower estimated capital expenditures (CAPEX) and associated depreciation. These results represent potential regional savings rather than a definitive assessment of current facility costs, as reliance on imported equipment and ingredients may introduce duties, taxes, and exchange-rate exposure not fully captured in the model.

Lower materials and maintenance costs also contribute to the modeled reduction. These savings more than offset modest cost increases in other categories, including slightly higher utilities and transportation costs in Brazil. Overall, the regional case studies suggest that production location can meaningfully affect current-state COGS, particularly when lower labor and capital costs reduce the per-kilogram cost of manufacturing.

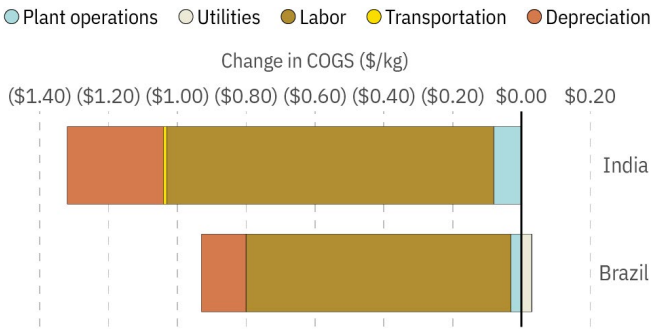


Figure 11: Regional COGS savings by cost category averaged across products. Contribution of each cost category to total COGS reductions in Brazil and India relative to the U.S. baseline.

For a full breakdown of assumptions and model results for Brazil and India, please see the regional case studies and Data workbook.

Future high-demand plant-based meat production costs

The future-state scenario assumes greater and more consistent consumer demand, driven in part by a better sensory experience. This higher-demand environment supports a combination of finished product facility scale up from 5,000 to 15,000 MTA with full facility utilization, lower product loss, and no CMO use. Ingredient prices were held constant with the exception of HME. Wheat gluten in the chicken nugget recipe was also commuted to the secondary protein system, which is assigned a baseline price consistent with LME. As such, scale is the primary driver of improvements in the future high-demand scenario.

These future-state manufacturing improvements substantially reduce COGS, but they do not close the parity gap for all products on their own (Table 10). Together, these changes lower COGS across all three product formats and bring plant-based ground beef below its modeled parity target by $0.60/kg. However, chicken nuggets and whole-cut chicken remain $0.65 and $0.92/kg above parity, respectively, suggesting that production optimization alone can narrow the cost gap but not fully close it without additional ingredient, formulation, or process improvements.

Table 10: Assumptions and COGS summary for future-state production. Results are shown in $/kg.

		Ground beef	Chicken nugget	Whole-cut chicken
Extrudate assumptions	**Extrudate type**	LME		HME
	Source	Ingredient supplier		
Extrusion facility assumptions	**Production volume**	50,000 MTA		
	Product split	67% LME		33% HME
	Plant utilization	100%		
	Product loss	10%		
Finished product facility assumptions	**Production volume**	15,000 MTA		
	Product split	50% ground beef	30% chicken nugget	20% whole-cut chicken
	Plant utilization*	100%		
	Product loss	10%		
Future COGS summary	**Future COGS**	$4.66	$4.42	$4.55
	Parity target	$5.26	$3.77	$3.63
	Difference	**$0.60 below parity**	**$0.65 above parity**	**$0.92 above parity**

*Plant utilization of 100% represents 82% plant uptime, equivalent to 300 operating days per year and assumed to reflect the industry-standard maximum annual operating schedule.

Savings in the future high-demand scenario are driven primarily by spreading capital and labor costs over more output, as well as reducing total input requirements through improved yield. The cost driver hierarchy remains similar in both current and future scenarios: ingredients remain the largest cost driver, driven by flavors and extrudate, followed by plant operations, labor, and depreciation. Importantly, the future scenario holds ingredient prices constant (Figure 12). As a result, the modeled COGS reductions reflect production-scale and efficiency gains rather than lower input prices. Ingredient savings in the future scenario come only from lower product loss, which reduces the total amount of input materials required per kilogram of finished product.

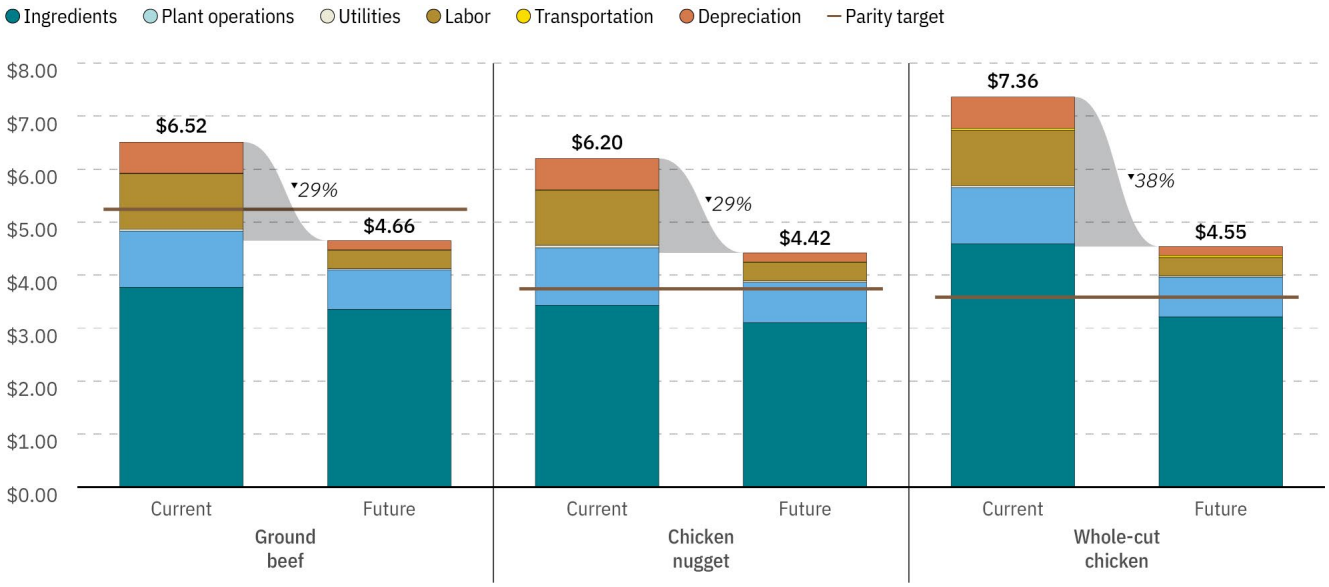


Figure 12: Cost drivers remain consistent between the current and future scenarios. Ingredients are the largest contributor to COGS, followed by plant operations, labor, and equipment depreciation. Utilities and transportation account for only a small share of total production costs.

Future-state ingredient pathways to lower production costs

The future scenario lowers production costs through scale and efficiency gains, but additional cost reductions are needed to reach parity across all three product formats simultaneously. The following case studies use the future high-demand scenario as the baseline and evaluate additional ingredient-driven cost-down pathways.

These future-state case studies examine the effect of formulation and ingredient price improvements (Table 11). Rather than predicting which specific ingredients, technologies, or processes will ultimately deliver taste parity, we grouped ingredients in the future recipes into broader ingredient categories while retaining the modeled weight percentages and baseline pricing data. This approach reflects the range of future ingredient systems that could be used to improve sensory performance, including improved flavor, fat, binder, and proteins, without over-specifying the exact technical solution.

Low-price protein, fat, and flavor pricing brings all products below parity

The first case study set protein, fat, and flavor systems to the low end of their modeled price ranges (Table 12). Binders, colors, preservatives, fortification, and breading ingredients were held constant at baseline pricing.

Table 11: Future-state case studies conducted to identify ingredient-driven cost reduction opportunities.

	Future-state assumption	Case study assumption
Case study #1 Ingredient pricing	Baseline prices	Low-end price flavors, fats, and secondary protein. Baseline price extrudate, binders, colors, preservatives, fortification, and breading.
Case study #2 Hybrid/blended protein	None	Replaces secondary protein and flavor ingredients.

This ingredient pricing scenario brings all three product formats below their modeled parity targets (Table 13). The result suggests that future cost competitiveness for nuggets and whole-cut chicken depends not only on larger, more efficient production, but also on ingredient systems that deliver improved sensory performance at lower cost-in-use or that replace other expensive ingredients, particularly flavors.

Table 12: Ingredient system pricing for future scenario case studies.

	Baseline Prices ($/kg)			Low Prices ($/kg)			
	Ground beef	Chicken nugget	Whole-cut chicken	Ground beef	Chicken nugget	Whole-cut chicken	Case Study
Secondary protein	$2.75	$2.75	$2.75	$1.50	$1.50	$1.50	Low
Binders	$2.11	$1.95		$1.56	$1.43		Base
Liquid Fats	$1.50	$1.50	$1.50	$0.75	$0.75	$0.75	Low
Structured Fats	$3.00			$1.00			Low
Flavors	$38.97	$37.45	$37.09	$8.91	$8.61	$8.62	Low
Colors	$40.83	$3.50		$28.33	$3.00		Base
Preservatives & Antioxidants	$5.66	$70.00	$0.75	$4.36	$60.00	$0.50	Base
Vitamins & Minerals	$3.36	$3.28	$3.28	$2.72	$2.69	$2.69	Base
Breading System		$1.13			$0.65		Base

Table 13: Future COGS + low protein, flavor, and fat ingredient pricing.

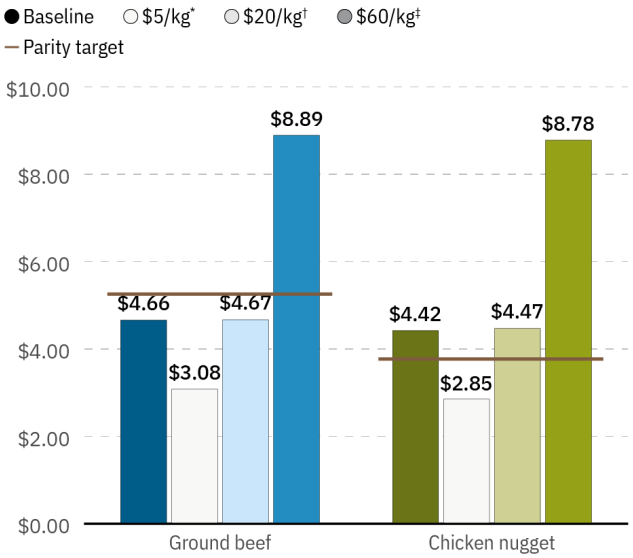
$/kg	Ground beef	Chicken nuggets	Whole-cut chicken
Future COGS + low ingredient pricing	$2.97	$2.84	$3.01
COGS parity target	$5.26	$3.77	$3.63
% difference	**$2.29 below parity**	**$0.93 below parity**	**$0.62 below parity**

Hybrid and blended ingredients must meet cost-in-use targets

A second case study explored using a hybrid or blended protein system to improve plant-based meat flavor performance and cost-in-use. In this scenario, the secondary protein system and the flavor system in the ground beef and chicken nugget formulations were replaced with an open-ended hybrid/blended ingredient system representing fermentation-derived, cultivated, or animal-derived ingredients. Together, these substitutions result in the hybrid/blended ingredient system comprising 9–10% of the final formulation.

The case study tested hybrid/blended ingredient prices of $5/kg, $20/kg, and $60/kg based on conventional meat parity targets, current biomass fermentation product pricing, and projected cultivated meat costs over the next 10 years.[9,10] At $5/kg, animal ingredients or low-cost mycoprotein that replaces flavor and secondary protein ingredients bring both ground beef and chicken nugget COGS below parity targets (Figure 13). At $20/kg, replacing secondary protein and flavor ingredients has little effect on total COGS, increasing costs by less than $0.05/kg. At $60/kg, however, COGS rise substantially, nearly doubling the baseline case.

These results suggest that hybrid and blended ingredients can bring plant-based meat below parity at the low end but must meet appropriate cost-in-use targets. Even when these ingredients improve sensory performance, their value depends on whether they can replace existing cost drivers, such as flavors or protein inputs, without pushing final product COGS further from parity.



*Animal ingredients, low-cost mycoprotein
†Fermentation-derived or cultivated ingredients
‡Cultivated ingredients

Figure 13: COGS falls below parity when 5% of LME and flavor ingredients are replaced by a hybrid/blended protein system priced at $5/kg. It remains mostly unchanged when the hybrid/blended protein system is priced at $20/kg but nearly doubles when it is priced at $60/kg.

TECHNOLOGY HIGHLIGHT:

Blended products can improve performance and economics

Offbeast has developed whole-cut beef tips containing 50% beef and 50% plant-based ingredients. Its Cross-Fiber Assembly platform has been adapted to combine lower-value animal inputs, such as ground beef or fat, with plant proteins to create a structured, muscle-like product. The plant-based portion acts as both a binder and an extender while maintaining protein content and meat-like texture. Offbeast positions this approach as a way to offer consumers a lower-cost product while improving margins for meat processors.

Although Offbeast uses a higher proportion of animal ingredients than the scenario modeled in this study, it illustrates the same underlying opportunity: hybrid and blended systems can improve sensory performance and economics when they replace costly inputs or increase the value of the finished product.

Price ceiling targets for ingredient innovation

The previous case studies showed lower ingredient costs enable parity across all products in a future high-demand scenario driven by improved sensory performance. However, achieving both price and performance improvements will require ingredient innovation that remains within viable cost-in-use limits. To provide concrete targets for innovation, the final future-state case study examines secondary ingredient price ceilings: the maximum price each ingredient system besides extrudate could reach while still allowing the product to meet its modeled parity target. Innovations above these ceilings are unlikely to be viable in similar formulations unless offset by savings elsewhere.

The basis of this case study is the maximum allowable secondary ingredient budget, calculated as the COGS parity target minus baseline extrudate cost and non-ingredient product costs from the future high-demand scenario. This calculation leaves a secondary ingredient budget of $3.41/kg for ground beef, $2.08/kg for chicken nuggets, and $1.10/kg for whole-cut chicken (Figure 14).

We then conducted this analysis one ingredient category at a time. For each category, the model calculated the maximum allowable ingredient system price if all other ingredient systems were held at high, baseline, or low pricing. When other ingredients are assumed to be at the low end of their modeled price ranges, each ingredient category has more room to contribute to COGS and therefore has a higher allowable ingredient price. When other ingredients are at baseline or high pricing, the allowable target ingredient price becomes more constrained. Figure 15 illustrates how the allowable prices were calculated for the flavor system in ground beef when all other ingredients were held at high, baseline, or low pricing. Figure 16 shows the summary of the same analysis applied to chicken nuggets and whole-cut chicken.

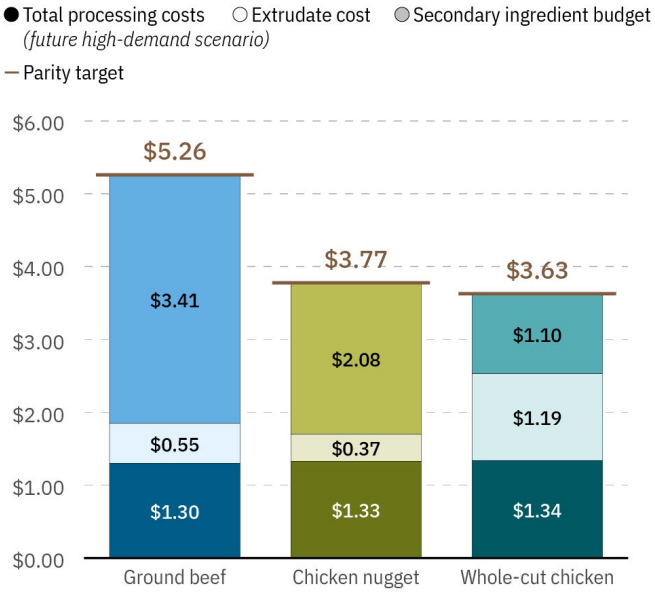


Figure 14: Maximum allowable secondary ingredient budget by product format.

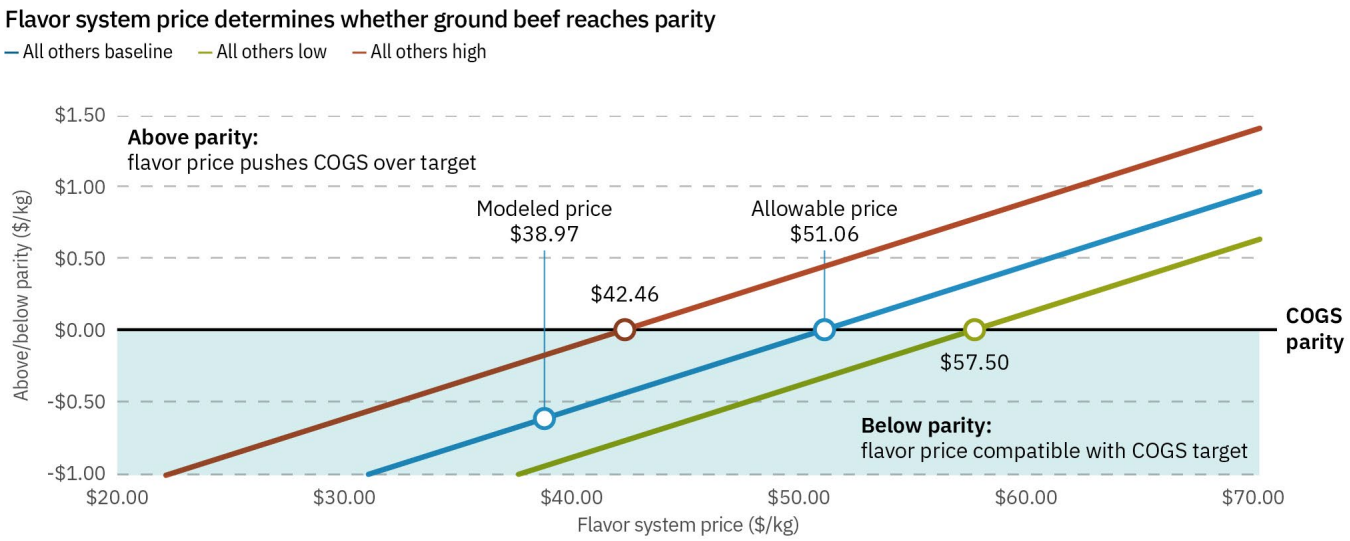


Figure 15: Allowable flavor system price is calculated for ground beef when all other ingredients are held at baseline, high, or low pricing based on the COGS parity target.

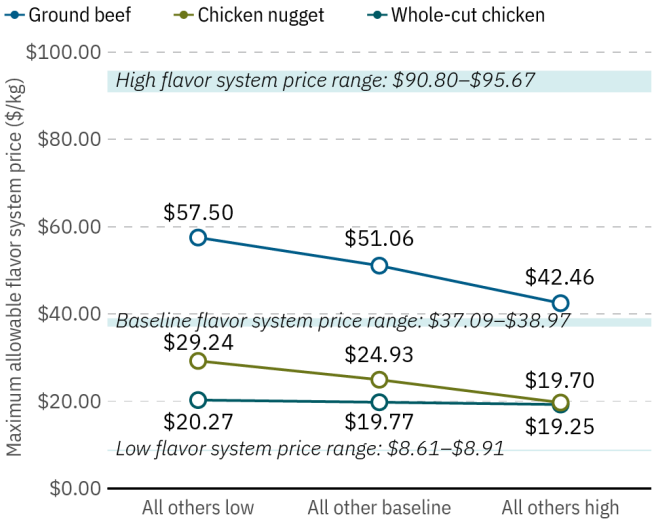


Figure 16: Maximum allowable flavor system price range by format.

The flavor system dominates ingredient costs across scenarios and formulations and therefore has an outsized effect on price ceilings available to other ingredient categories. Ground beef has the greatest flexibility because it is already below parity in the future high-demand scenario, allowing flavor costs to increase while maintaining parity. Chicken nuggets and whole-cut chicken begin above parity, so their flavor systems must instead fall below baseline costs for the products to reach parity. Whole-cut chicken is particularly constrained, with little tolerance for high-cost flavor systems even when other ingredients are priced at the low end of their modeled ranges.

Because ingredient price ceilings were calculated one category at a time, they represent trade-offs within a fixed formulation budget rather than prices that can all be achieved simultaneously. Table 14 shows these maximum allowable ingredient system prices under each ingredient pricing scenario excluding preservatives and fortification. The summary focuses on flavors, fats, secondary protein sources, binders, and colors, ingredients that are more likely to drive sensory improvements and where manufacturers have more discretion to choose among options at different price points.

Given the large range and important role of flavor prices, most ingredient systems have an allowable budget only when flavors are at the low end of the modeled range. When flavors are set to their baseline or high prices, setting other ingredient systems to $0/kg would not enable parity (denoted as N/A).

Table 14: Maximum allowable prices per kg ingredient for all ingredient categories by format and pricing scenario. Green values indicate room to grow over modeled baseline prices; red values indicate reductions needed to enable parity.

		Secondary protein	Binder system	Liquid fats	Solid fats	Flavor system	Color system	Breading system
Ground beef	Inclusion rate (wt%)	5.0%	13.5%	3.0%	4.0%	4.5%	0.3%	
	All others low	$45.23	$17.76	$73.64	$55.67	$57.50	$757.23	
	All others baseline	$13.63	$6.14	$19.63	$16.60	$51.06	$222.14	
	All others high	N/A	N/A	N/A	N/A	$42.46	N/A	N/A
Chicken nuggets	Inclusion rate (wt%)	5.0%	10.0%	1.0%		4.7%	0.1%	28.3%
	All others low	$20.89	$11.12	$97.70		$29.24	$972.46	$6.62
	All others baseline	N/A	N/A	N/A		$24.93	N/A	N/A
	All others high	N/A	N/A	N/A		$19.70	N/A	N/A
Whole-cut chicken	Inclusion rate (wt%)			3.0%		4.8%		
	All others low			$19.28		$20.27		
	All others baseline			N/A		$19.77		
	All others high			N/A		$19.25		
Modeled prices	Low price range	**$1.50**	**$1.43–1.56**	**$0.75**	**$1.00**	**$8.61–8.91**	**$3.00–28.33**	**$0.65**
	Baseline price range	**$2.75**	**$1.95–2.11**	**$1.50**	**$3.00**	**$37.09–38.97**	**$3.50–40.83**	**$1.13**
	High price range	**$4.50**	**$2.68–2.89**	**$2.25**	**$6.00**	**$90.80–95.67**	**$4.00–52.50**	**$1.58**

Overall, the results show that secondary ingredient innovation must be evaluated based on both performance and cost-in-use within the finished formulation. Flavor has the least cost flexibility and is therefore the most important ingredient target for cost reduction, particularly in chicken products. Lower-cost flavor systems can create room for higher-value structured fats, secondary proteins, binders, or colors, whereas expensive flavor systems can prevent parity even if other ingredient categories become more cost-competitive. Innovation should therefore focus not only on lowering the cost of individual ingredients, but also on designing combinations that deliver the greatest sensory benefit within the product's total ingredient budget.

TECHNOLOGY HIGHLIGHT:

Paragon Pure combines structured fat and flavor delivery

Paragon Pure's Olé-PBM is a structured marbling fat made from upcycled rice bran that is designed to improve juiciness and encapsulate flavor. The company reports that flavor encapsulation helps limit interaction between flavor ingredients and plant proteins, ultimately helping preserve flavor intensity while reducing the amount of flavor required.

This technology illustrates how multifunctional fat systems may justify a higher cost-in-use by improving sensory performance and replacing part of a costly flavor system.

Extrudate costs are driven by raw materials and CMO usage

To better understand what is driving extrudate prices, we modeled extrudate production scenarios for both current- and future-state environments (Table 15). Extrusion facility modeling indicates that extrudate production cost depends more on protein input costs and production environment than capital costs or throughput.

LME COGS remain approximately $2.10/kg across the current and future scenarios despite reduced production volume, with soy protein concentrate accounting for 85% of the cost (Figure 17). Labor, depreciation, plant operations, and utilities each contribute 5% or less, suggesting that extrudate costs are primarily a function of raw material costs rather than processing costs. Future HME COGS fall from $2.54/kg to $1.13/kg when production moves from a contract manufacturer to a dedicated facility. Once produced within a large ingredient facility, HME costs less than LME because its higher moisture content reduces the amount of soy protein concentrate required per kilogram. Although HME requires more costly extrusion lines, depreciation still accounts for only 15% of HME COGS. Adding breaker plates and gas injection technology does not meaningfully drive HME equipment costs but can contribute to sensory improvements.

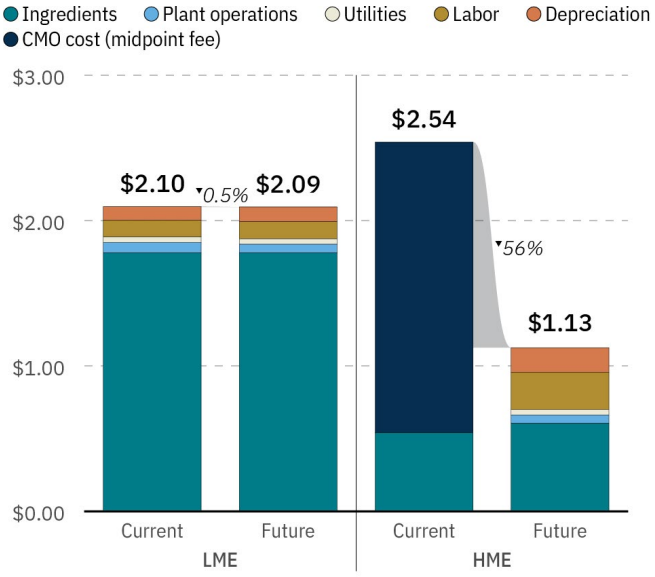
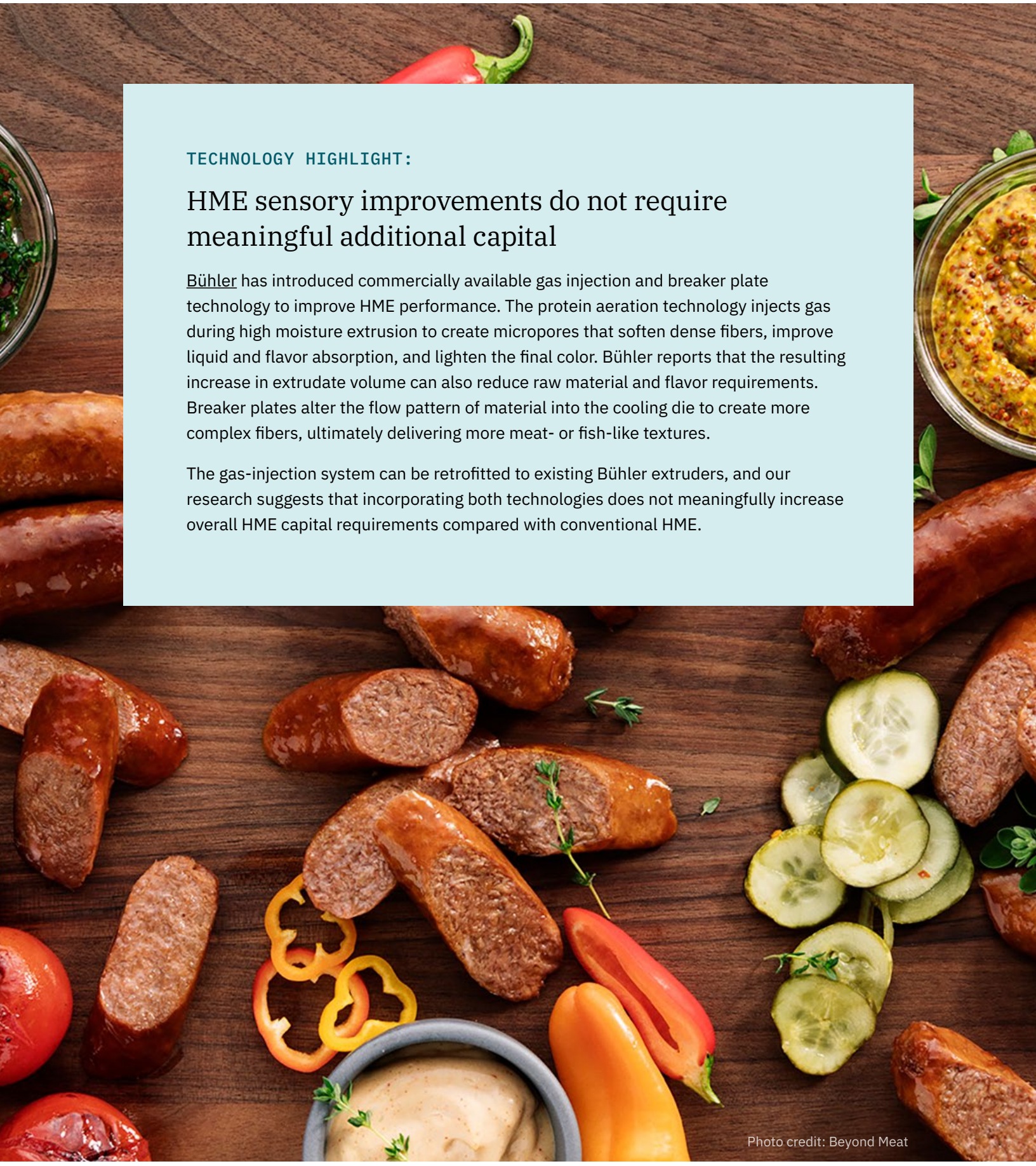


Figure 17: Summary of extrudate COGS results.

Table 15: Summary of extrusion facility assumptions.

	Current-state extrusion facility	Future-state extrusion facility
Production volume	50,000 MTA	
Product split	100% LME*	67% LME 33% HME
Plant utilization	100%	
Product loss	10%	

*In the current-state extrusion facility scenario, 100% of production is dedicated to LME. HME production is modeled at a brand-contracted CMO. For more on this assumption, see the techno-economic analysis design section.



TECHNOLOGY HIGHLIGHT:

HME sensory improvements do not require meaningful additional capital

Bühler has introduced commercially available gas injection and breaker plate technology to improve HME performance. The protein aeration technology injects gas during high moisture extrusion to create micropores that soften dense fibers, improve liquid and flavor absorption, and lighten the final color. Bühler reports that the resulting increase in extrudate volume can also reduce raw material and flavor requirements. Breaker plates alter the flow pattern of material into the cooling die to create more complex fibers, ultimately delivering more meat- or fish-like textures.

The gas-injection system can be retrofitted to existing Bühler extruders, and our research suggests that incorporating both technologies does not meaningfully increase overall HME capital requirements compared with conventional HME.

Photo credit: Beyond Meat

Case studies conducted on the future-state extrusion facility further indicate that production capacity and equipment throughput have comparatively modest effects on extrudate COGS (Table 16). The first case study reduced production capacity to assess whether a smaller or brand-owned facility could remain cost competitive with a large ingredient manufacturer. The second examined whether investing in higher-throughput extrusion equipment could meaningfully reduce production costs.

	Future-state assumption	Case study assumption	LME cost impact	HME cost impact
Case study #1 Production capacity	50,000 MTA	10,000 MTA	+$0.44/kg (+21%)	+$0.62/kg (+55%)
Case study #2 Extrusion throughput	LME: 3,000 kg/h HME: 1,000 kg/h	LME: 4,500 kg/h HME: 2,000 kg/h	-$0.03/kg (-1%)	-$0.08/kg (-7%)

Table 16: Summary of future extrusion facility case studies.

Case Study #1: The higher COGS at a smaller scale is driven primarily by labor and depreciation being spread across less output. Plant operations also contribute to the increase, though to a lesser extent. Even so, the resulting COGS remains in the same general range as the larger-scale scenario, suggesting that smaller extrusion facilities can still produce cost-competitive extrudate. Notably, producing HME alongside LME at small scale still significantly reduced the cost of production compared to CMO production. Larger facilities improve cost efficiency but are not the only viable pathway to competitive extrudate production.

Case Study #2: Case study throughput values exceed currently reported maximums and were selected as stretch cases to test the potential COGS impact of major equipment productivity improvements. This had only a modest effect on COGS, lowering costs by $0.03 and $0.08/kg (1–7%), respectively, driven primarily by lower labor and CAPEX depreciation allocated to each kilogram of extrudate. Because ingredients remain the dominant cost driver for both LME and HME, higher throughput alone does not substantially change extrudate production costs.

Together, these findings suggest that extrusion is relatively capital efficient and that lower ingredient costs and reduced reliance on contract manufacturing offer greater cost-reduction potential than further increases in facility or equipment scale.

TECHNOLOGY HIGHLIGHT:

Less-refined protein inputs could reduce extrudate costs

Nexnoa has developed an extrusion process that directly converts soy flour into structured, fibrous ingredients without relying on concentrates or isolates. The company reports that its proprietary Flow-Texturization Technology creates meat-like dry extrudates that easily absorb liquid and seasonings for stable juiciness and demonstrate consistent behavior at any scale.

Directly texturizing less-refined, lower-cost raw materials targets the largest extrudate cost driver while simplifying upstream processing.

Capital intensity is not a primary cost barrier

Moderate scale up delivers capital efficiency gains

CAPEX is another important driver of production economics. CAPEX reflects the equipment, facility, and infrastructure investment needed to manufacture at commercial scale, and influences how much depreciation is allocated to each kilogram of product. Capital efficiency, calculated as total capital investment divided by annual production capacity, helps assess how efficiently these investments scale, enables comparison across facilities and manufacturing approaches, and helps determine whether capital expense reduction is needed.

Figure 18 shows the current finished product facility CAPEX. The total investment of approximately $22M for the 5,000 MTA facility is largely driven by process equipment, especially freezing and packaging equipment and breading and frying equipment.

Building and facility costs are the next largest contributor, followed by other construction project indirect costs. The capital efficiency of the current facility is $4,400/MTA, or $4.40/kg.

In the future scenario, CAPEX increases by approximately 75% to $39M while production volume increases 300%, from 5,000, to 15,000 MTA (Figure 19). The formulation facility therefore has a capital efficiency of $2,600/MTA, or $2.60/kg. The larger facility significantly improves capital efficiency primarily because CAPEX does not scale linearly with capacity (i.e., the larger facility achieves high economies of scale). The CAPEX increase is concentrated in the same categories that dominate current capital costs: processing equipment—especially freezing and packaging equipment—followed by breading and frying equipment and expanded building and facility costs.

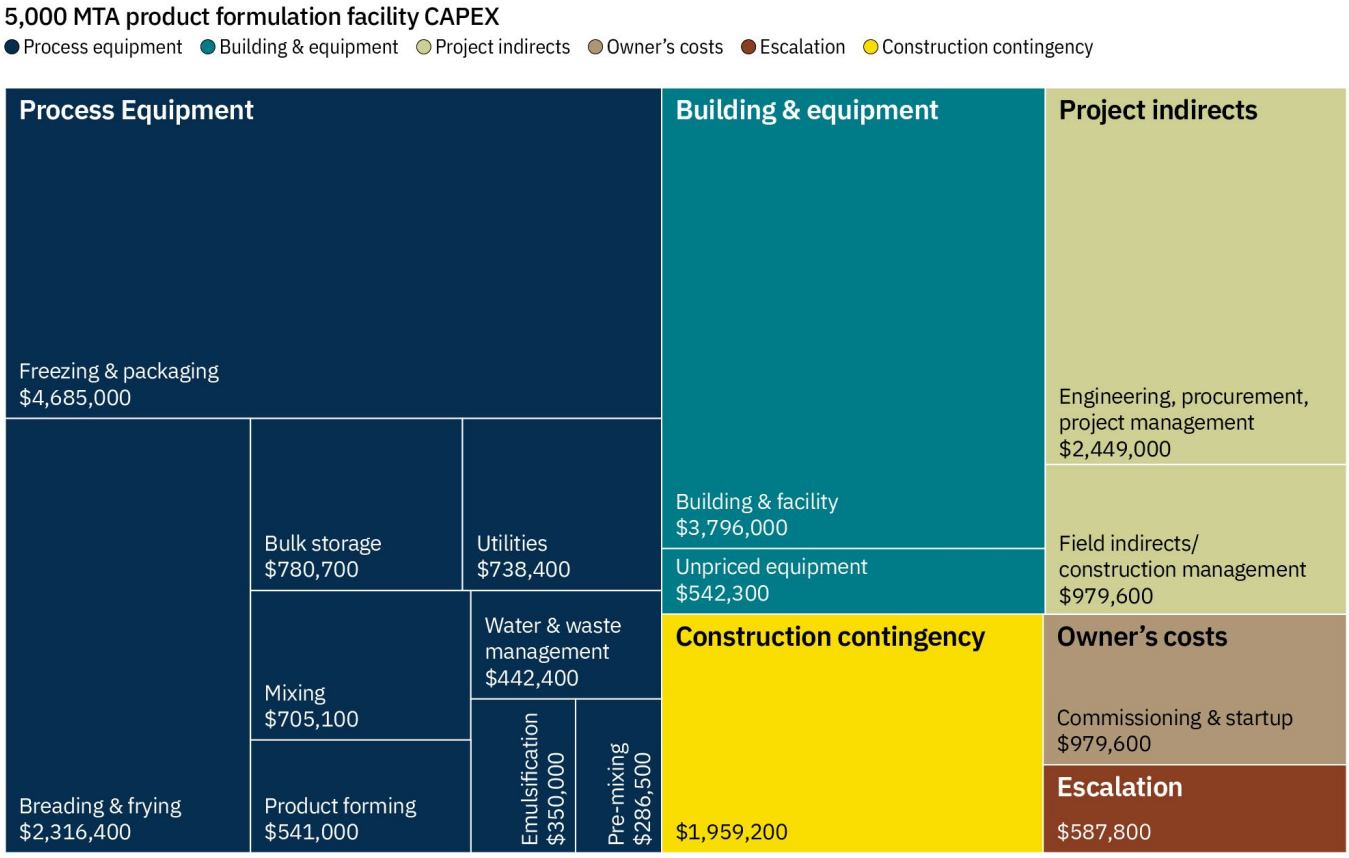


Figure 18: Current product formulation facility capital expenses.

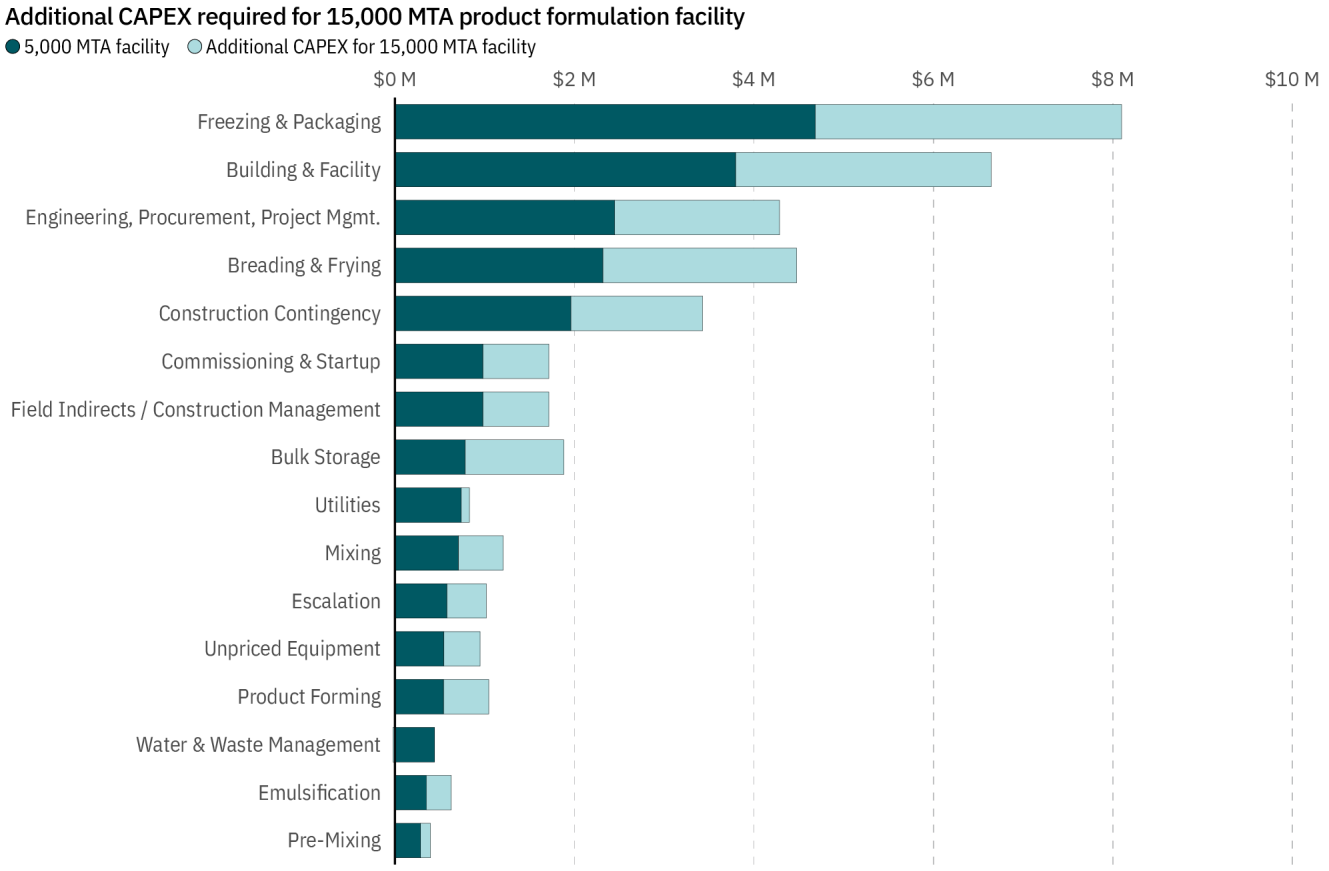


Figure 19: Additional CAPEX requirements for the future scenario 15,000 MTA product formulation facility.

*Wastewater equipment is sized to meet the average hourly demand. The future facility operates for more hours, so wastewater generation is spread over a longer period, resulting in a slightly reduced average hourly demand and smaller required equipment size.

Plant-based and conventional meat have similar capital efficiency

Plant-based meat facilities appear similar in capital efficiency to conventional meat production and likely better than biomass fermentation or cultivated meat facilities. Comparing capital efficiency across production approaches helps contextualize the investment required to add manufacturing capacity and assess whether capital expense reduction is a central need for plant-based meat. To enable comparison, we adjusted all reported CAPEX values to January 2026 U.S. dollars using U.S. Bureau of Labor Statistics data before calculating capital efficiency

Across the facilities modeled in this study and GFI's plant-based meat manufacturing capacity analysis—including both product formulation and extrusion—capital efficiency for plant-based meat production facilities ranges from approximately $1,000 to $4,400 per MTA of nameplate capacity. Extrusion facilities are at the lower end of this range, while the current product formulation facility modeled in this analysis is at the higher end. This range is broadly consistent with reported capital efficiency for conventional meat production facilities, which falls between $1,000 and $6,000 per MTA based on recent press releases.[11–15]

Reported capital efficiency for aerobic biomass fermentation generally ranges from approximately $4,000 to $36,000 per MTA, while cultivated meat estimates range from approximately $11,000 to over $100,000 per MTA (Figure 21). These wider and generally higher ranges provide broader context but should not be interpreted as controlled comparisons with plant-based meat, as the facilities differ in scope and output. The plant-based estimates include both ingredient extrusion and finished-product formulation, while the biomass fermentation estimates represent ingredient production, and cultivated meat facility boundaries vary. Biomass fermentation and cultivated meat manufacturing are also still maturing.

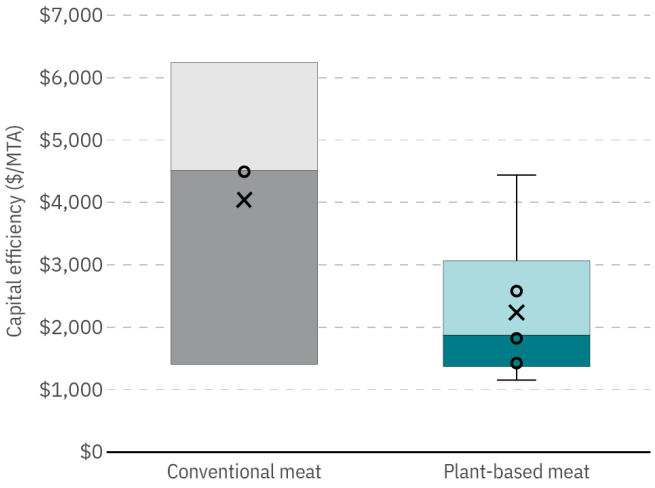


Figure 20: Plant-based and conventional meat have similar capital efficiency.

Many estimates reflect low-volume or prospective facilities, and actual capital requirements remain highly uncertain until more commercial facilities are built and their costs validated.

Within these constraints, the comparisons suggest that current extrusion-based plant-based meat does not face unusually high capital requirements and that further reductions in capital intensity are not a primary need. With low technical execution risk and high capital efficiency, its cost challenge is driven more by utilization, scale, product loss, ingredient costs, and operational efficiency. Though emerging or novel production technologies may have different capital requirements and may need capital efficiency improvements, our research suggests that targeted investment in near-term production can deliver significant cost reductions, improve unit economics, and increase product competitiveness.

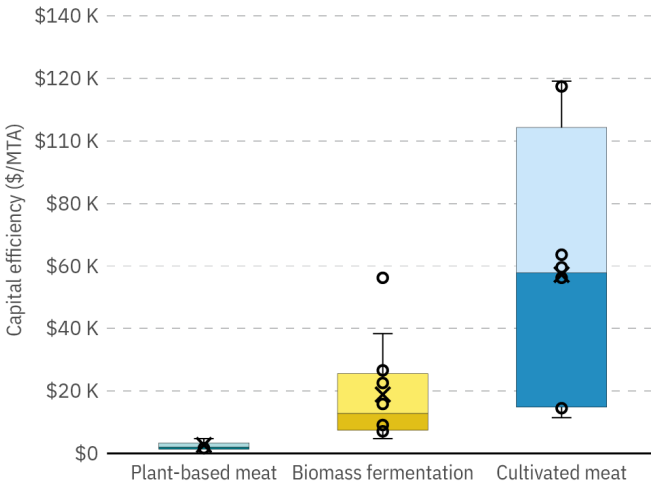


Figure 21: Capital efficiency of the plant-based meat facilities modeled here compared to reported ranges for conventional meat, biomass fermentation, and cultivated meat.



Photo credit: Tofurky

Calls to action

The path to parity for plant-based meat depends on coordinated progress across manufacturers, researchers and ingredient developers, investors, and policymakers. The following suggested calls to action outline how stakeholders across the plant-based meat ecosystem can help move these priorities forward together. For more details on these proposed actions, see executive summary.

Based on this key finding...	We recommend the following actions for...			
	Plant-based meat manufacturers and partners	**Researchers and ingredient developers**	**Investors**	**Policymakers**
CMO can lower COGS with favorable fees	Use low-cost CMOs where quality can be maintained.		Prioritize operational enablers like shared infrastructure models and yield-optimizing technologies.	Establish or expand loan, loan guarantee, tax incentive, and grant programs to support efficient commercial-scale manufacturing. Support shared infrastructure.
Operational efficiency improvements reduce near-term COGS	Generate value from idle capacity by contracting production for similar products.			
Plant capacity further reduces COGS but requires high demand	Co-manufacture with legacy producers using existing facility production lines.			
Ingredients are the largest cost driver, driven by flavors and extrudate	Reduce formulation costs by testing lower-cost extrudates and flavor systems.	Advance protein solutions to improve flavor neutrality and enable greater use of less-refined ingredients. Develop cost-effective flavor systems and solid fat alternatives to tropical oils.	Invest in cost-effective ingredient innovation, with a focus on flavor.	Fund open-access research to optimize ingredients for flavor
HME produced at scale brings down whole-cut costs		Enable larger-scale production and distribution of HME ingredients.	Invest in companies scaling sensory-enhanced HME.	
Multifunctional hybrid ingredients can bring COGS below parity		Design multifunctional hybrid ingredients that replace existing cost drivers		

References

1. Ghosheh M et al. Metamaterial-based injection molding for the cost-effective production of whole cuts. Nature communications. 2024 ;15(1):10767.

2. Jarunglumlert T et al. Techno-economic assessment of plant-based meat analogue produced by the freeze alignment technique. Future Foods. 2023 Nov 9:100269.

3. Kontovas S, Misailidis N, Petrides D. Soybean Refinery – Process Modeling and Techno-Economic Assessment (TEA) using SuperPro Designer. 2023. https://www.researchgate.net/publication/368603517_Soybean_Refinery_-_Process_Modeling_and_Techno-Economic_Assessment_TEA_using_SuperPro_Designer. https://doi.org/10.13140/RG.2.2.23856.64002

4. Allotey DK et al. Techno-eco-environmental Assessment of Dry Fractionation of Protein Concentrates from Yellow Peas with Different Pre-treatment Methods: An Eco-efficiency Approach. Journal of cleaner production. 2024 Apr 25:142298.

5. Khaitan P. From Cultivar to Consumer: An Integrated Environmental, Nutritional, and Economic Analysis of Pea-Based Meat Analogues. [Montreal] : McGill University Libraries, [2026]. 2026. https://bac-lac.on.worldcat.org/oclc/1600267618?lang=en

6. Li Y et al. Techno-economic analysis of protein concentrates production from brewer's spent grains. Bioresource Technology. 2026;464(Pt A):135687.

7. Warner A. Plant Based Meats – The Battle for Price Parity. 2024. https://www.new-foodinnovation.co.uk/price-parity

8. Taste of the Industry 2025 — Nectar. https://www.nectar.org/sensory-research/2025-taste-of-the-industry

9. Cultivated meat LCA/TEA report analysis. The Good Food Institute. https://gfi.org/resource/cultivated-meat-lca-tea-report-analysis/

10. Techno-economic insights on fermentation ingredients. The Good Food Institute. https://gfi.org/resource/techno-economic-insights-on-fermentation-ingredients/

11. Department Directory. So you want to build a slaughter plant? Department of Animal Science. 2020 July 7. https://animalscience.tamu.edu/department-updates/so-you-want-to-build-a-slaughter-plant/

12. Epstein-Designed Prestage Foods Facility Completes Construction. Epstein. 2019 May. https://www.epsteinglobal.com/news/epstein-designed-prestage-foods-facility-completes-construction

13. Wright County, IOWA. https://www.wrightcounty.iowa.gov/departments/economic_development/major_employers.php

14. Spielman S. How Prestage Foods of Iowa built a state-of-the-art pork processing plant. 2019 Dec 9.https://www.foodengineeringmag.com/articles/98612-prestage-farms-built-a-state-of-the-art-pork-processing-plant-in-northwest-iowa

15. Oatman R. Sustainable Beef holds ribbon cutting ceremony for $400 million plant. 2025 Mar 27.https://www.meatpoultry.com/articles/31660-sustainable-beef-holds-ribbon-cutting-ceremony-for-400-million-plant

Regional case studies

Brazil

A case study of regional techno-economics of plant-based meat production.



Brazil could offer a lower-cost manufacturing environment for plant-based meat

Modeled COGS are lower than the U.S. base case across all three products.*

Ground beef	Chicken nuggets	Whole-cut chicken
$5.62/kg	**$5.31/kg**	**$6.46/kg**

$0.90/kg lower COGS

~14% reduction compared to the U.S. base case

*Modeled products can represent regional equivalents with similar sensory, production, and nutritional profiles.

Cost advantage is driven by lower labor for facility operation, construction, and equipment installation

Case study facility parameters

- 5,000 MTA capacity
- 50% Ground beef
- 30% Chicken nuggets
- 20% Whole-cut chicken
- 50% Plant utilization
- 20% Product loss

What does it cost to build a plant in Brazil?

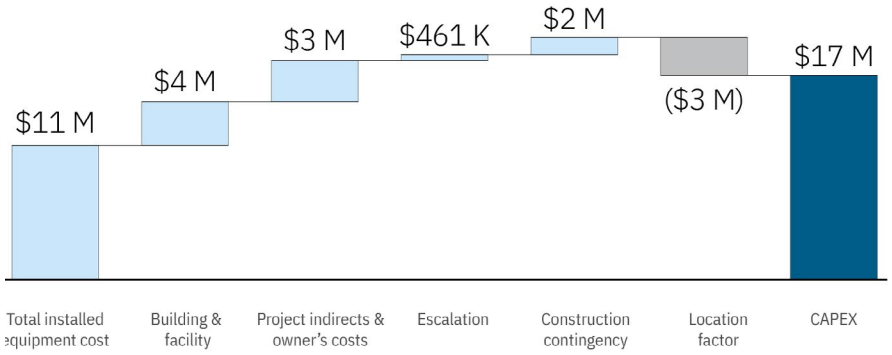
Modeled CAPEX for a 5,000 MTA product-formulation facility

$17.4 M†
Modeled total CAPEX

21% lower than the U.S. base case

Regional assumption	Brazil to U.S. factor	% of CAPEX
Building costs	0.99	25%
Process equipment	1.00	39%
Equipment installation	0.44	18%
Construction labor	0.40	18%
Weighted location factor	**0.79**	

CAPEX breakdown for 5,000 MTA facility in Brazil



†Equipment costs may be affected by import duties and taxes, freight, local installation requirements, and exchange-rate fluctuations.

What does it cost to operate a 5,000 MTA plant in Brazil?

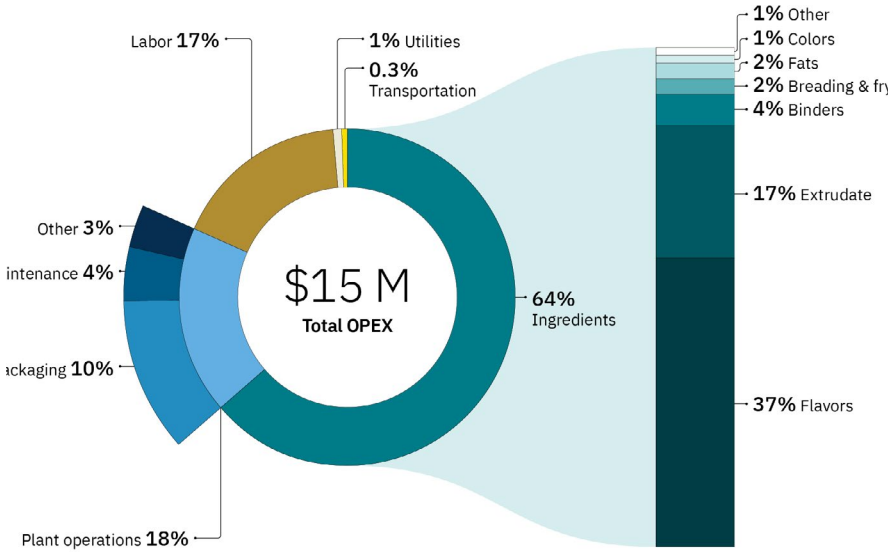
Annual operating expenses at 50% utilization and 20% product loss

$13 M
Annual modeled OPEX

14% lower than the U.S. base case

What drives OPEX?

- Ingredients, driven by flavors and extrudate
- Plant materials, primarily packaging
- Plant labor



What drives Brazil's manufacturing advantage?

70% lower labor cost

On average, compared to U.S. Midwest

21% lower construction cost

On average, compared to U.S. Midwest

Abundant protein supply

Ready access to soy protein ingredients

Established food manufacturing

Domestic production and ready access to standard food processing equipment

Key uncertainties

- **Local cost of equipment:** Assumed to be the same as the U.S. Midwest. Equipment costs may be affected by import duties and taxes, freight, local installation requirements, and exchange-rate fluctuations, which could increase actual CAPEX relative to the estimates presented here.
- **Local manufacturing conditions today:** Assumed U.S. base case operating conditions, which reflect underutilized, small-scale facilities resulting from a low-demand environment.
- **Local cost of non-extrudate ingredients:** Local prices for non-extrudate ingredients may differ from those modeled. Some specialty ingredients and additives may rely on imports and therefore be affected by import duties and taxes, freight costs, and exchange-rate fluctuations, which could increase the cost of ingredients relative to estimates presented here.
- **Domestic availability of CMOs for high moisture extrudate (HME) production:** Assumes HME is produced via CMO for whole-cut chicken; HME-based products in Brazil are uncommon.

India

A case study of regional techno-economics of plant-based meat production.



India could offer a lower-cost manufacturing environment for plant-based meat

Modeled COGS are lower than the U.S. base case across all three products.*

Ground beef	Chicken nuggets	Whole-cut chicken
$5.21/kg	**$4.90/kg**	**$6.05/kg**

$1.31/kg lower COGS

~20% reduction compared to the U.S. base case

*Modeled products can represent regional equivalents with similar sensory, production, and nutritional profiles.

Cost advantage is driven by lower labor for facility operation, construction, and equipment installation and construction and lower building material costs.

What does it cost to build a plant in India?

Modeled CAPEX for a 5,000 MTA product-formulation facility

$11.8 M†
Modeled total CAPEX

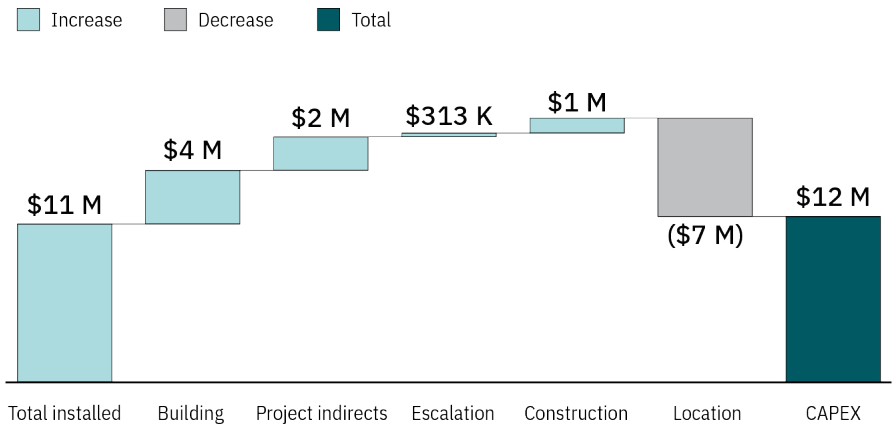
47% lower than the U.S. base case

Regional assumption	India to U.S. factor	% of CAPEX
Building costs	0.30	25%
Process equipment	1.00	39%
Equipment installation	0.24	18%
Construction labor	0.15	18%
Weighted location factor	**0.53**	

Case study facility parameters

- 5,000 MTA capacity
- 50% Ground beef
- 30% Chicken nuggets
- 20% Whole-cut chicken
- 50% Plant utilization
- 20% Product loss

CAPEX breakdown for 5,000 MTA facility in India



†Equipment costs may be affected by import duties and taxes, freight, local installation requirements, and exchange-rate fluctuations.

What does it cost to operate a 5,000 MTA plant in India?

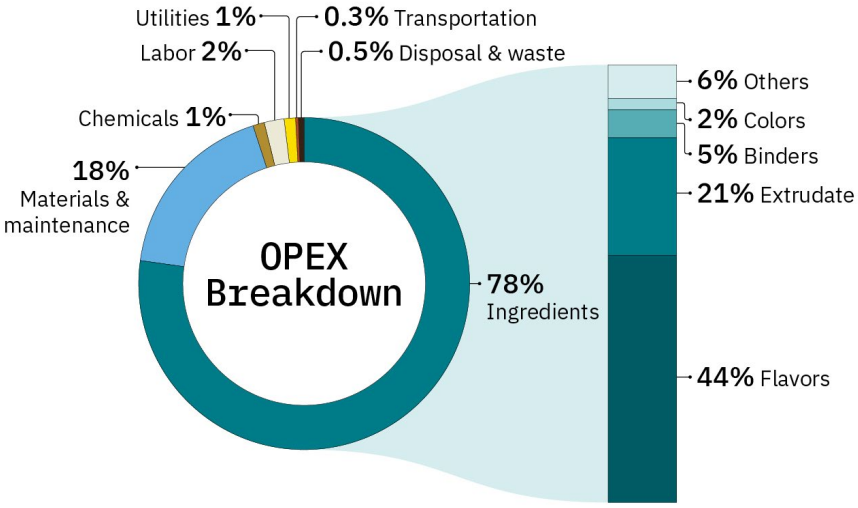
Annual operating expenses at 50% utilization and 20% product loss

$12.4 M
Annual Modeled OPEX

17% lower than the U.S. base case

What drives OPEX?

- Ingredients, driven by flavors and extrudate
- Plant materials, primarily packaging



What drives India's manufacturing advantage?

90% lower labor cost

On average, compared to U.S. Midwest

57% lower construction cost

On average, compared to U.S. Midwest

Abundant protein supply

Ready access to soy protein ingredients

Established food manufacturing

Domestic production and ready access to standard food processing equipment

Key uncertainties

- **Local cost of equipment:** Assumed to be the same as the U.S. Midwest. Equipment costs may be affected by import duties and taxes, freight, local installation requirements, and exchange-rate fluctuations, which could increase actual CAPEX relative to the estimates presented here.
- **Local manufacturing conditions today:** Assumed U.S. base case operating conditions, which reflect underutilized, small-scale facilities resulting from the low-demand environment.
- **Local cost of non-extrudate ingredients:** Local prices for non-extrudate ingredients may differ from those modeled. Some specialty ingredients and additives may rely on imports and therefore be affected by import duties and taxes, freight costs, and exchange-rate fluctuations, which could increase the cost of ingredients relative to estimates presented here.
- **Domestic availability of CMOs for high moisture extrudate (HME) production:** Assumes HME is produced via CMO for whole-cut chicken.

Appendix

Key assumptions and limitations

Assumption or simplification	Limitation or implication
Extruded soy product focus This analysis examines plant-based meat that relies on extruded soy protein as its primary base. It does not cover varying inputs or texturization technology.	Results should not be generalized to products made using other proteins or structuring technologies, which may have different ingredient, equipment, throughput, labor, and capital requirements.
Representative product formats This analysis models plant-based ground beef, chicken nuggets, and whole-cut chicken as representative ground, restructured, and simple whole-cut products.	While the product formats can be generalized across regions and eating cultures, they do not represent the full range of plant-based meat formats. Product formats with different form factors, compositions, or processing requirements may have significantly different costs.
Hypothetical formulations Recipes were chosen based on aggregated information from interviews, labels, public disclosures, and literature. They do not represent any individual commercial product.	Actual product formulations are proprietary and vary across manufacturers. Modeled COGS represents estimates rather than the cost of producing a specific commercial product.
Fixed formulations Inclusion rates are held constant within each modeled product except where a case study explicitly notes otherwise.	The analysis does not capture reformulation in response to changing ingredient prices, availability, or performance. Future-scenario results therefore reflect changes in production assumptions without formulation optimization. Price ceilings represent the maximum ingredient price at the modeled inclusion rate. An ingredient used effectively at a lower inclusion rate could support a higher price per kilogram, while one requiring a higher inclusion rate would need a lower price to achieve the same cost-in-use target.

Representative ingredient prices Ingredient prices are held constant between current and future scenarios. They reflect 2024–2026 wholesale and international trade data, validated through expert interviews and supplier quotes. Baseline, low, and high prices were derived from representative figures within each range.	Prices vary by supplier, specification, purchasing volume, contract terms, geography, and market conditions. Individual manufacturers may face costs outside the modeled ranges. The model also does not explicitly link prices to purchasing volume, though the ranges may capture some volume effects.
Defined production scenarios and operating conditions The current and future scenarios use specified assumptions for facility capacity, utilization, product mix, product loss, throughput, operating schedule, and production technology. Equipment is sized based on the average throughput required under each scenario.	The results represent steady-state performance under the modeled conditions rather than forecasts of industry development or the performance of a specific facility. They do not fully capture ramp-up, unplanned downtime, short production campaigns, changeovers, or other operating variabilities. Achieving the future scenario also depends on sufficient demand to support the assumed capacity and utilization.
Defined operating-cost boundary The model includes raw materials, utilities, production labor, materials and maintenance, waste disposal, and other costs within the facility inside battery limits. Non-production organizational roles are treated as overhead outside the modeled labor estimate.	The analysis excludes connected infrastructure and some business-level costs, including sales, R&D, and administrative personnel. In practice, modeled COGS may assume some of these costs depending on the company's operating model.
Capital cost estimates Capital costs are developed using equipment factors, parametric models, vendor information, and Next Rung Technology's historical equipment-cost database. Equipment costs are scaled to the required capacity using the six-tenths rule.	The estimates are consistent with a blend of AACE Class 4 and Class 5 practices and have a targeted accuracy range of ±25–30%. Actual project costs will depend on site conditions, final engineering, equipment selection, procurement, construction timing, and other project-specific decisions.

Conventional COGS parity targets Conventional meat COGS were derived from wholesale prices and processing benchmarks using a different methodology for each product format. Adjustments to isolate ground beef and chicken breast COGS rely on publicly available financial data from Tyson Foods, while the chicken nugget target is inferred from retail prices and an estimated COGS-to-retail markup.	These targets depend on several allocation and processing assumptions and are not directly observed industry-wide COGS values. These targets depend on several allocation and processing assumptions and are not directly observed industry-wide COGS values. Tyson Foods' cost structure may not represent all conventional meat processors. The additional assumptions required for chicken nuggets create greater uncertainty for that target. The targets reflect the mainstream/standard segment; parity targets for premium products would be higher. Conventional COGS also vary across producers, regions, product specifications, and market conditions.
Regional case studies adjust selected cost categories The Brazil and India case studies adjust utility, labor, and building costs. Capital adjustments were derived using a blended capital cost factor, while ingredient prices were held constant.	These case studies compare current production economics across selected relevant markets, not fully optimized regional production. The results represent potential regional savings rather than a definitive assessment of current regional facility costs, as reliance on imported equipment and ingredients may introduce duties, taxes, and exchange-rate exposure not fully captured in the model.
Labor requirements Labor is estimated assuming one operator for each major piece of process equipment per shift, with staffing divided among skilled and unskilled operators, mechanics, quality control technicians, foreman, and plant managers.	Actual staffing requirements will vary with facility design, automation, equipment integration, production complexity, company practices, and local labor conditions.
U.S. Midwest cost basis The model assumes U.S. Midwest rates for labor, utilities, and other location-dependent operating or capital costs.	Costs may differ in other locations due to variations in wages, utility rates, construction costs, transportation, taxes, and infrastructure. The baseline results should therefore not be treated as representative of every U.S. or international production location.
2026 cost basis All financial inputs, including ingredient prices, labor rates, utilities, equipment costs, and other capital and operating costs, are normalized to a 2026 U.S. dollar cost basis.	Results represent costs in 2026 U.S. dollars and do not account for subsequent inflation, commodity-price fluctuations, wage changes, exchange-rate movements, or other changes in market conditions. Costs should be updated before applying the findings to a different time period.

Expanded methods

For detailed TEA methodology, see the full technical whitepaper.

For a detailed breakdown of recipes, ingredients, and results, see the Data workbook.

Modeling approach and data sources

This study uses a bottom-up techno-economic modeling approach to estimate the cost of producing plant-based meat products. We developed process flow diagrams for each modeled facility to define the major unit operations from extrusion through final mixing and packaging. Researchers used product formulations, annual volumes, and process yield assumptions to construct mass balances, size equipment, and calculate raw material requirements.

The primary outputs of the model are cost of goods sold (COGS), based on operating expenses (OPEX), and capital expenses (CAPEX). COGS is determined by combining ingredient costs with plant operating costs, such as packaging, maintenance, labor, depreciation, transportation, and utilities. It is calculated based on assumptions about production volume, facility utilization, product loss, and labor requirements. The model reports factory-gate COGS and excludes downstream distribution and retail costs. CAPEX is estimated based on the equipment and facilities required for each process, which are scaled to reflect the modeled production volume.

Both primary and secondary data inform this analysis. Primary data refers to information collected directly for this study, primarily through over 40 interviews with plant-based meat manufacturers, ingredient suppliers, researchers, and other technical experts in extrusion, contract manufacturing, and food manufacturing scale up. We conducted these interviews to validate process assumptions and refine model inputs related to ingredient pricing, formulations, supply chain, and plant operations. In addition, Bühler Group provided a primary dataset on extrusion processing, which informed assumptions related to extrusion inputs, throughput, yields, and operating parameters. Secondary data refers to existing information from sources such as academic and industry literature, commercial ingredient pricing, engineering cost and scaling factors, and regional data for labor and utilities.

COGS parity targets

A defensible, context-driven baseline is needed to make meaningful COGS comparisons between conventional meat and plant-based alternatives. Conventional meat COGS were derived from wholesale prices and processing benchmarks using three methodologies:

- Chicken breast: Costs were determined using a framework based on biological mass balance standards (Cobb500) and 2025 USDA wholesale spot prices (sourced via USDA AMS_3646). Shared upstream processing costs were allocated proportionally by revenue share to ensure premium cuts reflect their production burden.
- Ground beef: Ground beef was modeled as a single-stream assembly process where the finished product absorbs 100% of localized costs. COGS were derived from average annual wholesale prices for packaged 2025 USDA 81% ground beef blocks (sourced via USDA LM_XB403).
- Chicken nuggets: Due to a lack of reliable wholesale data, the average 2024 retail price for conventional nuggets, tenders, and wings ($4.90 per pound, according to GFI analysis of SPINS data*) was divided by the average COGS-to-retail markup (2.8) derived from the chicken breast and ground beef models.

For both chicken breast and ground beef, final manufacturing costs were adjusted using audited annual Tyson Foods Form 10-K segment- and corporate-level data. This step isolates factory-gate COGS by removing centralized corporate overhead (SG&A) and consolidated operating profits.

*SPINS Natural Enhanced Channel + SPINS Conventional Multi Outlet Channel + SPINS Convenience Channel (powered by Circana) | 52 Weeks Ending 12-1-2024. Based on custom categories that were created by refining standard SPINS categories.

CMO-only COGS estimation

CMO conversion fees were estimated from interviews with plant-based meat companies, technical experts, and former industry advisors. Although several interviewees noted that CMO fees can rival or exceed ingredient costs, our research suggests that these fees are typically charged per kilogram of product rather than as a percentage of ingredient costs. Based on the reported ranges, HME conversion fees were modeled at $0.83–$4.00/kg, with a baseline of $2.00/kg. Finished-product conversion fees were modeled at $1.32–$5.00/kg. The low end was based on non-ingredient production costs in the future-state finished-product facility and was consistent with the lower end of interview estimates.

CMO-based COGS were calculated by adding the applicable conversion fee to ingredient costs and assuming 10% product loss, reflecting relatively efficient production at specialized contract manufacturers.

Post-production costs — detailed findings from interviews

Production costs represent only a fraction of what consumers actually pay at retail stores and restaurants. In interviews with more than 40 companies, investors, and researchers, post-production costs emerged as a significant driver of end-product prices. Brand markups, distributor fees, broker commissions, and steep retail and foodservice margins frequently combine to push final prices to more than double the factory-gate COGS. While not the primary focus of this study, a brief exploration of key post-production cost drivers helps explain the gap between plant-based meat's production costs and shelf prices (Figure 22).

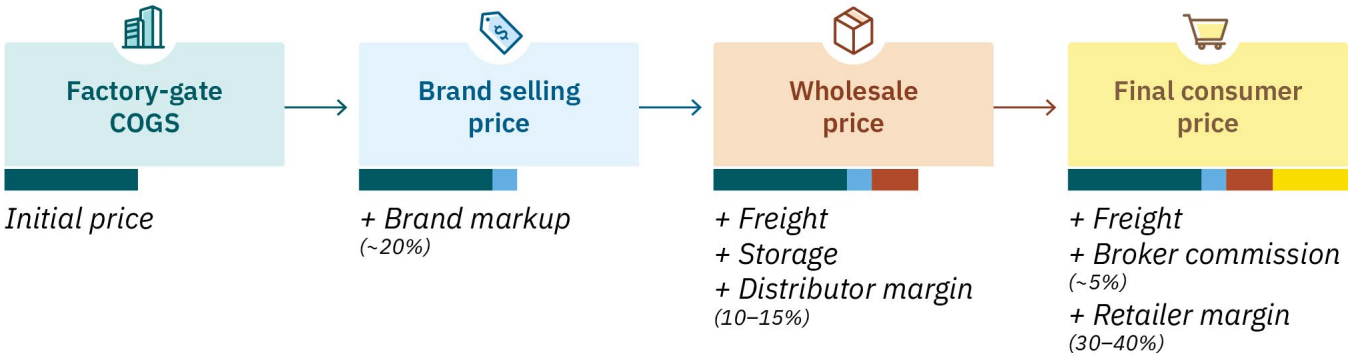


Figure 22: End-product price accumulation pathway.

Costs compound at each stage of the value chain. Industry interviews highlighted several drivers of these post-production expenses:

Brand markup and pricing strategy

Early-stage companies face pressure to recover heavy upfront investments in R&D, intellectual property, and marketing. To pay back these investments, brands apply a minimum markup to their factory-gate costs. This markup is frequently around 20%, according to industry interviews. In some cases, brands may price their products at a further premium to generate additional marginal revenue and clear the path for scale up. Interviewees noted that mature companies without historical R&D burdens may be able to apply lower markups.

Logistics, scale, and cold chain

Logistics costs depend heavily on where production and distribution are located, as well as on the scale of distribution. Small brands shipping via refrigerated less-than-truckload (LTL) or individual pallets face significantly higher freight rates—sometimes as much as $1,000 per pallet for mid-to-long haul routes. By contrast, large incumbents leverage volume scale to ship dedicated full truckloads (FTL) at $2,500 to $4,200 per 53-foot trailer, bringing their effective freight cost down to just $115 to $210 per pallet. Additionally, current plant-based products mostly rely on chilled or frozen supply chains, which can double total costs compared to shelf-stable alternatives. The frozen chain introduces high storage costs, complex logistics, and financial risks from product spoilage and expiration. Shipping plant-based meat products in shelf-stable formats–such as canned or otherwise heat-processed products, dried ready-to-eat products like jerky, ambient-stable vacuum-packed products, or dry products intended for rehydration–can eliminate the cold chain, but these formats are not common in most markets.

Channel distribution and retail barriers

The journey from distributor to retail shelf is complex and costly. In the United States, small brands often must hire brokers to secure meetings with grocery stores, and each intermediary along the chain adds a margin. Distributors, for example, commonly apply a flat 15 to 20% markup regardless of volume. As a brand grows, distributors can occasionally require higher markups that reflect the brand's capacity to pay.

Several interviewees noted that supermarkets often exact the largest margins in the chain. Slow inventory turns, high slotting fees (paying for shelf space), in-store advertising costs, and product wastage for many plant-based meat products mean retailers may expect at least 30 to 40 percentage points in margin for plant-based proteins.

Foodservice and alternative routes

Foodservice and white-label channels generally present a lower-cost path to market than retail. While direct-to-consumer online models bypass grocery intermediaries, individual shipping costs can be prohibitive. In contrast, foodservice allows brands to ship in large packaging volumes, eliminating retail slotting fees and high marketing costs. Consequently, brands may achieve higher margins in foodservice than retail, but this can vary by foodservice operator.

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 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. To learn more, please visit gfi.org.

GFI.ORG / POWERED BY PHILANTHROPY

GFI is a nonprofit 501(c)3 organization.

©2026 The Good Food Institute, Inc. All rights reserved. Permission is granted, free of charge, to reproduce GFI-authored content from this report for noncommercial educational purposes with attribution to The Good Food Institute. Third-party content, including photographs, graphics, and quoted material, is subject to separate rights and permissions.