MBOLD
Protein Catalyst

INDUSTRIAL HEMP

Opportunities and Challenges for Use as an Animal Feed Ingredient

September 2026

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ABOUT THIS REPORT

As part of its Protein Catalyst initiative, the MBOLD Coalition commissioned an assessment to evaluate opportunities to incorporate industrial hemp seed meal into animal feed rations and contribute to the sustainability of animal agriculture through the development and inclusion of more sustainable feed ingredients.

While bringing new crops to market and into animal feed rations is often a long and complex process, MBOLD is committed to building the knowledge base and exploring how crops like industrial hemp can become a viable and valuable option for both farmers and supply chain stakeholders. Gaining a better understanding of industrial hemp meal's safety and performance in various animal species' diets is central to this effort and to enabling scale on the landscape.

This report aims to capture the current state of knowledge on industrial hemp meal's potential as an animal feed ingredient. The information was gathered from industry participants, researchers, animal nutrition specialists, supply chain stakeholders, and available literature. The findings aim to inform growers, agronomists, supply chain participants, policymakers, feed mills, nutritionists, and livestock operators as they evaluate hemp seed meal's potential for agricultural diversification and sustainable intensification.

Acknowledgments

AURI extends its sincere thanks to the MBOLD Coalition for its leadership, guidance, and support throughout the project and to the Builders Initiative and McKnight Foundation for providing funds to MBOLD that made the work possible. This report has been shaped by the valuable contributions of multiple collaborators including members of the MBOLD animal protein feed ingredients team and animal nutrition experts who generously shared their insights and guidance. We would also like to express our thanks to LEIF LLC for its sustainability assessment as a key contribution to this report. MBOLD thanks our animal feed ingredients team for their deep feed ingredient and industry expertise and collaboration, which informed development of this report.

EXECUTIVE SUMMARY

Demand for animal protein continues to rise, placing increasing pressure on feed systems to deliver both performance and sustainability. Novel feed ingredients such as industrial hemp, referred to throughout this report as "hemp" — and specifically hemp seed meal (HSM) — offer a potential pathway to diversify feedstocks while contributing to environmental goals. This report evaluates the opportunities and challenges associated with incorporating HSM into livestock diets, drawing on industry interviews, ration modeling, and a review of current research.

HSM has a promising nutritional profile, including relatively high protein content, beneficial fatty acids, and a favorable omega-6 to omega-3 ratio. Nutritionists identified additional potential advantages such as anti-inflammatory properties and functional benefits in certain species. However, the ingredient also presents key limitations, including low lysine content, higher fiber levels in mechanically pressed meal, and variability in digestibility. Concerns regarding trace contaminants — particularly the presence and potential transfer of cannabinoids into animal-derived food products—remain a critical barrier to broader adoption. Economic viability is a central constraint. Based on 2025 market conditions, modeling indicated that mechanically pressed HSM would be priced at a substantial discount to soybean meal — between 40% to 75%, depending on the species—to be competitive in feed rations. This pricing dynamic, driven by fiber content, amino acid balance, and energy characteristics, represents a significant hurdle for widespread commercialization.

From a regulatory standpoint, progress has been made, with an AAFCO definition existing for mechanically pressed HSM inclusion of up to 20% in laying hen diets, subject to cannabinoids limits[1]. However, expansion into additional species remains contingent on generating sufficient safety and performance data, as well as navigating state-level and federal regulatory pathways. Regulatory approval beyond poultry — particularly for swine and cattle — will be a critical determinant of market scale.

Among evaluated species, laying hens represent the most immediate and viable entry point, given current regulatory approval and favorable economic alignment relative to other species. Turkeys also show promising early signals based on digestibility and performance indicators, though additional research is required. Broader adoption across species will depend on demonstrating consistent nutritional performance, safety, and cost competitiveness.

Industrial hemp also offers potential environmental benefits, including reduced input requirements relative to many other crops and the possibility of achieving carbon-negative production under certain conditions. However, most lifecycle assessments have been conducted outside the United States, and regionally relevant data — particularly for the Upper Midwest — is needed to validate these sustainability claims and support market adoption.

[1] The Association of American Feed Controls Officials (AAFCO) approved a definition (T71.5) for mechanically pressed HSM inclusion in laying hen diets at up to 20% with limits on cannabinoids levels of 2 ppm and 20 ppm, respectively.

Looking ahead, the successful commercialization of HSM as a feed ingredient will depend on coordinated progress across several fronts. Key priorities include:

1. **conducting species-specific feeding trials** to validate safety and optimize inclusion rates—particularly for broilers and turkeys;
2. **evaluating the nutritional and economic differences between mechanically pressed and solvent-extracted HSM;**
3. **assessing the potential for cannabinoid accumulation** or pass-through into meat, milk, and eggs; and
4. **developing regionally relevant lifecycle assessments to substantiate sustainability benefits.**

In parallel, continued advancement in industrial hemp genetics — particularly through hybridization to improve grain yield and consistency — will be essential to enhancing its economic competitiveness. Combined with expanded regulatory approvals and improved supply chain coordination, these developments could enable HSM to emerge as a viable, sustainable feed ingredient within targeted segments of the livestock industry.

Testing tissues and products for cannabinoid presence is occurring as part of feeding trials and needs to continue to fill this information gap. New standards and testing applications are being developed by commercial laboratories and academic institutions.

At the time of this report, there was no apparent commercial solvent-extracted processing occurring or indications from existing processors of a transition from mechanical to solvent extraction methods. As hemp acreage and production increase, solvent-extracted processing on dehulled hemp seeds will require additional research and regulatory efforts.

Overall, HSM presents a credible but conditional opportunity: its long-term role in animal feed systems will depend on addressing regulatory, economic, and technical barriers while building confidence through targeted research and commercialization efforts.

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INTRODUCTION

The UN FAO estimates that by 2050 (using 2010 as a base), demand for food will grow 60% due to rising populations and income, with animal protein demand rising 1.7% per year. This equates to a 70% increase in meat production, 90% for aquaculture, and a 55% rise in dairy demand (IFIF, 2025; World Bank, 2025).

Global meat production was estimated at 365 million metric tons in 2025 and is projected to reach 406 million metric tons by 2034 (OECD/FAO, 2025) and 455 million metric tons by 2050 (FAO, 2012). This increased demand is driven by population growth (set to reach 9.6 billion by 2050), urbanization, and rising incomes (Milford, Le Mouël, Bodirski, & Rolinski, 2019; Suzuki & Pirlea, 2025). Animal feed production was estimated at 1.4 billion tons in 2025 (IFIF, 2025), with U.S. feed production estimated at 270 million tons in 2024 (Alltech, 2025). More sustainable solutions for animal feed, which comprises a large share of animal agriculture's environmental footprint, will be important in helping reduce agriculture's emissions, along with land and water use, to enhance supply chain and planetary resilience.

Today's livestock diets rely heavily on corn and soybeans, often alongside other ingredients, such as canola and alfalfa. Soybeans and corn have achieved increased yields and production through many years of research and development that have improved their productivity and economic competitiveness as well as their sustainability profiles, yet the environmental footprint of corn-soybean production systems remains an area of active discussion. The development of hybrid seed for industrial hemp will increase the yield of grain per acre, which will improve its sustainability profile, economic competitiveness, and availability for feed applications.

Animal nutrition researchers began investigating the use of industrial HSM as a sustainable feed ingredient due to its rich content of essential and non-essential amino acids, fiber, and healthy fats. Its nutritional profile is rich in essential fatty acids, protein, and other bioactive compounds (Alonso-Esteban, et al., 2023), suggesting potential benefits when incorporated into animal diets. Hemp coproducts such as hemp cake, hemp hulls, and spent hemp biomass (SHB) can also provide protein, fiber, and energy sources to support the livestock industry.

The regulatory approval required to expand hemp ingredient utilization in animal feed markets has been a significant barrier. AAFCO added a tentative ingredient definition for mechanically extracted HSM for laying hens in 2024, and the definition was officially published in the AAFCO Official Publication in August 2025 (Feed & Grain, 2025). While progress has been made, a press release from the Hemp Feed Coalition[2] notes that AAFCO's approval "does not grant automatic state-level acceptance," and the regulatory path to market "remains riddled with bureaucratic obstacles." (HFC, 2025a)

This report explores the opportunities and challenges of including HSM in livestock feeds for beef, dairy, swine, and poultry (broiler chickens, laying hens, and turkeys), including nutritional, anti-nutritional, regulatory, and initial supply chain considerations. The findings are based on a combination of interviews with animal nutritionists, supply chain participant perspectives, researchers, animal feed users, feed rationing software programs, and literature reviews.

[2] HFC is a collaboration actively pursuing federal policy support to improve and expand regulatory approval pathways to additional species

MARKET POTENTIAL FOR NOVEL INGREDIENTS

Animal feed consumption data released in February 2025 (IFEEDER, 2025) indicated U.S. livestock, poultry, and aquaculture feed consumption was 284 million short tons in 2023 (excluding forages and roughages). Of the non-forage and roughages fed, approximately 200 million short tons were corn-based ingredients, with the next largest ingredient being soy-based. Over time, corn inclusion rates have decreased, while soy-based inclusion rates have increased.[3]

Using Minnesota as an example, over 23 million short tons of animal feed were consumed in 2023 across the state (Table 1). Forages and roughage accounted for 9 million tons of that feed, while commercial and on-farm feed mills processed the remaining 14 million tons. Corn-based feed ingredients made up 44% of feed consumed in the state, with soybean-based feed ingredients accounted for approximately 8%. (Figure 1).

HSM was not listed as a commonly used feed ingredient in Minnesota during 2023, the time covered by these estimates, which predates its 2024 AAFCO tentative approval status. However, these numbers provide insight into potential market opportunities for HSM. Soybean meal is typically included in laying hen diets at roughly a 20 percent rate, so incorporating a 20 percent inclusion of HSM to match the current AAFCO approval level for laying hens would translate to roughly 63,000 short tons of feed demand in Minnesota if it replaced estimated soybean meal usage on a 1:1 basis.

Ingredient Class	Quantity (Short Tons)	% of Total
Corn-Related	10,590,870	44.3%
Forages & Roughage	9,100,023	38.1%
Soy-Related	1,958,907	8.2%
Processed Plant Co-Products	697,102	2.9%
Small Grains	534,505	2.2%
Vitamins & Minerals	325,519	1.4%
Other Plant-Based Meal	231,547	1.0%
Fats & Oils	206,561	0.9%
Animal Byproduct Meals	196,351	0.8%
Other Feed Ingredients	42,816	0.2%
Synthetic Amino Acids	30,680	0.1%
Unique Ingredients from Aquaculture	94	<0.1%
Total, All Classes	**23,914,975**	**NA**

Table 1: *Estimated Animal Feed Consumption in Minnesota by Ingredient Class, 2023. (DIS, 2025)*

[3] The shift in inclusion rates is reported generally and does not specifically point to why this shift is occurring, for example, from an industry focus on biofuels and resulting additional meal available.

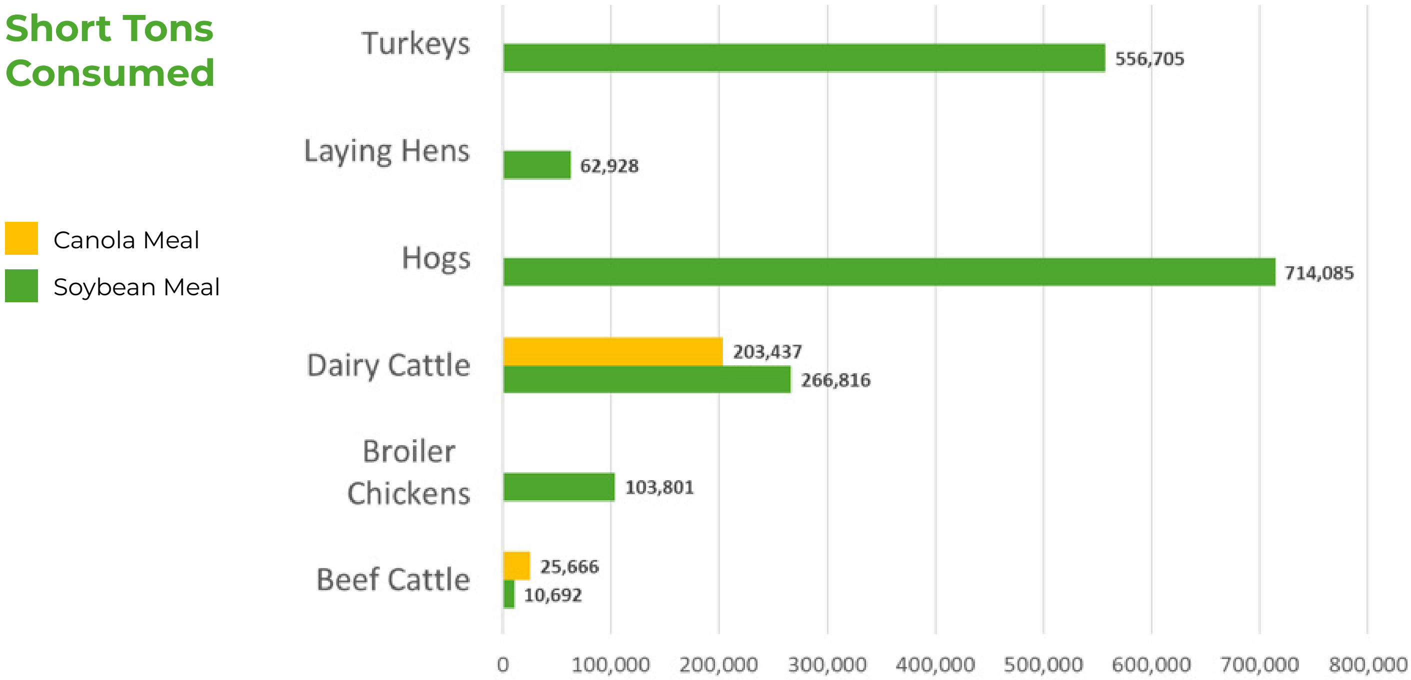


Figure 1: *Estimated Canola and Soybean Meal Consumption by Species in Minnesota, 2023. (IFEEDER, 2025)*

HEMP AS A FEED INGREDIENT

HSM's composition and its nutritional, technical, and functional properties are crucial for determining how it fits into formulated feed. Understanding the manufacturing processes is also relevant, as post-harvest handling and processing influence the composition, quality, and functional properties. This report focuses mainly on HSM but also explores hemp seed, oil, hulls, and spent biomass.

Hemp Seed Meal (HSM)

HSM is a coproduct obtained from the oil extraction process. Mechanically pressed HSM typically contains around 35% crude protein, 10%-15% fat, 7-8% ash, and 20-25% crude fiber. Research shows HSM to be rich in amino acids, particularly arginine, glutamic, and aspartic acids (Mohamed & House, 2024, p. 390).[4]

Sometimes called "cake", mechanically pressed HSM is considered a good feed source for ruminants, poultry, and equine. While there is potential for swine feeds, mechanically pressed HSM inclusion in swine diets may be limited due to the higher content of residual unsaturated fatty acids. Swine feed will need to use solvent-extracted HSM to lower residual fat percentages. The omega acid content in mechanically pressed HSM may be good for poultry diets, enabling producers to meet demand for high-omega eggs for health-conscious consumers.

The HSM amino acid profile is deficient in lysine, an obstacle that may be addressed by blending with other complementary ingredients during ration formulation, such as soybean meal or limited amounts of synthetic feed-grade lysine. HSM's relatively high protein and fat content from mechanical pressing may also open opportunities as a protein and energy source for the pet food industry.

[4] The most essential amino acids for livestock are lysine, methionine, threonine, valine, arginine, and tryptophan.

Dehulling

Dehulling represents a processing step that may enhance the nutritional profile of hemp seed–derived feed ingredients by removing the outer hull, which contains a high proportion of indigestible fiber and associated antinutritional compounds. Removal of this fraction concentrates protein, reduces crude fiber, and increases the relative energy density and digestibility of the remaining seed "hearts." As a result, dehulled hemp seed products may offer improved suitability for inclusion in monogastric animal diets, where lower fiber and higher nutrient availability are important formulation considerations. The dehulling process for hemp seeds can be effectively achieved by using impact-based systems followed by aspiration and screening to separate the hulls from the hearts, producing distinct coproduct streams with differing nutritional characteristics.

At the same time, dehulling introduces trade-offs in downstream processing. The absence of the structural fiber provided by the hull limits the effectiveness of mechanical pressing, as the dehulled seed lacks sufficient internal friction to support efficient pressing. This can result in reduced oil recovery and operational challenges, including clogging within mechanical press systems. In contrast, whole hemp seed with intact hulls can be processed more effectively using conventional mechanical extraction, producing both oil and a higher-protein meal. These findings suggest that while dehulling may improve the nutritional quality of hemp-based feed ingredients, alternative processing approaches—such as solvent extraction—may be required to fully realize the full value of the hemp seed. Further work is needed to evaluate these approaches and to better understand the resulting meal characteristics and potential applications in feed systems.

Other Hemp Feed Ingredients

While this report focuses on HSM, other potential feed ingredients derived from industrial hemp are shown below, including hemp seed, hemp oil, spent hemp biomass, and hemp hulls.

Hemp seed is a good source of macronutrients (proteins, fats, and fiber), minerals (P, K, Mg, Ca, Na, Fe, Mn, Zn, Cu), and phytonutrients (tocopherols, carotenoids, and sterols). Hemp seed antioxidants, including polyphenols, flavonoids, and tocopherols may improve the oxidative stability of animal-derived feed products. Additionally, hemp seed contains omega-3 and omega-6 fatty acids, which have anti-inflammatory properties (Kapoor & Huang, 2006), and can increase conjugated linoleic acid (CLA) content in milk (Gebereyowhans, 2024).

Hemp seed oil is extracted from the seeds, typically through mechanical pressing. It is a rich source of polyunsaturated fatty acids, particularly essential ones such as linoleic acid (60%) and alpha-linolenic acid (19%). Hemp seed oil has been shown to enrich animal products, supporting its use in poultry diets where higher energy levels are required. Researchers also note that its gamma-linolenic acid content may further enhance its nutritional value by improving the omega-6 to omega-3 fatty acid ratio and support healthier metabolic balance (Callaway, 2004, p. 70).

Spent hemp biomass is a coproduct that remains after the extraction of cannabinoids from the hemp flower (inflorescences). It contains high levels of protein and energy and may provide an excellent roughage feedstock for ruminants (Parker, et al., 2022). Concerns on utilizing spent hemp biomass in feed is mainly around the higher cannabinoid presence in this biomass material.

Hemp hulls are a coproduct of dehulling hemp seeds. Hulls are the removed husk or seed coat and could serve as a soluble fiber and protein feedstock.



Commercializing Novel Feed Ingredients

AAFCO has an established ingredient definition for “Industrial Hemp Meal, Mechanical Extracted” (AAFCO T71.5), for use in diets of laying hens at an inclusion rate of no more than 20%, less than or equal to 20 ppm total CBD, and less than or equal to 2 ppm total THC (AAFCO, 2025a).

Commercializing novel feed ingredients requires more than simply having an AAFCO ingredient definition. It is a complex, multi-stage process that requires coordinated technical, regulatory, and market development efforts. Key steps include:

- **Understanding nutritional performance:** New animal feed ingredients must be evaluated for their nutritional value, protein quality, fiber, energy levels, digestibility, and antinutritional factors to determine how they fit into species-specific diets.
- **Safety assessment:** Alternative feed ingredients are tested at various inclusion rates to assess safety concerns related to dietary incorporation for a specific animal species.
- **Regulatory approval:** In the United States, multiple pathways exist for securing premarket approval of novel feed ingredients. In addition to FDA’s Generally Recognized as Safe (GRAS) framework, AAFCO has introduced a new review pathway, the Scientific Review of Ingredient Submissions (SRIS).[5] However, regulatory pathways remain lengthy, costly, and complex, especially when international harmonization is lacking.[6]
- **Optimization assessments:** Feed will also be evaluated for its efficiency in different species at various rates and at different life stages to minimize costs and maximize performance, while also taking into consideration the matrix effects, including the presence of fiber components, antinutrients, etc.

Studies investigating the safety and efficiency of using HSM as an animal feed ingredient have been conducted across multiple livestock species. A safety assessment is critical because hemp can contain heavy metals, cannabinoids, and other metabolites that impact the metabolism, growth, and health of animals. While the presence of cannabinoids is found mainly in the flowers and leaves, research needs to demonstrate that feeding HSM does not result in appreciable levels in consumable products, such as meat, milk, eggs, etc.

[5] AAFCO introduced a new animal food ingredient review process after its memorandum of understanding with FDA expired in October 2024. AAFCO partnered with Kansas State University’s Olathe Innovation Campus (K-State Olathe) to establish the SRIS pathway for review of new animal food ingredient definitions and modifications to existing definitions (SRIS, 2026) It began accepting applications in October, 2025 (AAFCO, 2025b). Under SRIS, K-State Olathe provides scientific review through expert panels that make recommendations to the AAFCO membership for final approval. Once approved by AAFCO, the ingredient definition is added to the AAFCO Official Publication (OP). AAFCO does not approve, certify, or endorse finished animal food products, but it does approve ingredient definitions for inclusion in the OP. FDA and state feed control officials retain legal authority over animal food and feed ingredients (AAFCO, 2025c).

[6] For example, discrepancies in the approval and classification of the pelleting aid lignosulfonate—used to improve feed texture and reduce dust—have created barriers to global market entry. While lignosulfonate is approved in the U.S. as a feed ingredient, its classification and data requirements vary significantly across jurisdictions such as the EU, Canada, and China, complicating international trade and regulatory compliance.

Optimized feeding trials to illustrate efficiency will ultimately enable more accurate analysis of how HSM affects growth rates and overall animal performance, allowing for direct comparisons with other feed ingredients.

Alongside regulatory clearance and commercial validation, market development is critical. This includes feeding trials, processing demonstrations, safety assessments, performance testing in end-use applications, and targeted stakeholder engagement with processors, manufacturers, retailers, and consumers. Collaborations with industry partners, academic institutions, and early adopters help generate the data and case studies needed to build confidence across the value chain. Certifications and third-party verifications can further enhance credibility and market access, thereby accelerating trial and adoption.

At every stage of this process, economic considerations shape stakeholder decisions and influence adoption. Farmers assess return on investment and risk; processors evaluate throughput costs and infrastructure needs; regulators consider safety and regulatory compliance; retailers and end-users weigh price-performance tradeoffs and market positioning. Understanding these dynamics is essential to aligning incentives and ensuring the crop's long-term success across the supply chain (National Institute of Food and Agriculture, 2025).

The Hemp Feed Coalition, a non-profit organization focused on gaining approvals for hemp as an animal feed ingredient, has actively engaged with stakeholders to help accelerate the approval of hemp as a feed ingredient through collaborative research and data-sharing efforts.

OVERVIEW ON HSM INCLUSION IN ANIMAL FEED

Through this research, AURI explored the potential for HSM to be incorporated into feed rations across multiple species[7]. AURI interviewed 11 nutritionists, researchers, and feed manufacturers to gather insights for including HSM in animal diets. All nutritionists were aware of the potential use of hemp as a feed ingredient and considered it effective in formulations at up to 20% of a species' diet.[8]

Overall, nutritionists had favorable comments on its use, provided barriers to successful adoption can be overcome. Industry participants interviewed identified four important factors for including HSM as an innovative protein ingredient in animal diets:

- **Value:** Energy and protein are the most expensive nutrients in a formulation; therefore, an interviewee noted, "any product that can effectively deliver digestible amino acids or energy at a competitive price to traditional ingredients may have interest among manufacturers."
- **Antinutritional factors:** The presence of trace contaminants, including metals, cannabinoids, and other secondary metabolites, raises questions about their secondary effects on animal performance as well as their potential presence in consumer-purchased products.
- **Consistency of supply:** Interviewees noted the importance of a consistent and adequate supply volume for new sustainable ingredients.
- **Nutrient content:** Characteristics such as energy, amino acids, and phosphorus concentrations may provide additional opportunities for HSM.

[7] Emerging research from Dr. Ruggero Amato (University of Naples Federico II) may indicate there is a niche market for hemp as a feed additive, with initial results showing improved stress tolerance and increased milk production in goats.

[8] Note – this does not imply regulatory acceptance at 20% but is a theoretical indication of how much HSM could be included in a ration.

Amino acids form the foundation of protein, and it is crucial to understand the amino acid composition to evaluate protein quality and ensure an animal's diet is balanced to support optimal growth, development, and overall health. Additionally, information on nutrient digestibility estimates, including amino acid digestibility, is critical in an optimized and meaningful feed formulation.

Nutritionists typically use ration-balancing software to optimize ingredient mixes against nutritional and energy targets by species. These programs provide valuable insights into the desired percentage and cost to optimize outcomes. These models can also be forced to theoretically accept an ingredient and provide valuations on the price point needed to work into a feed ration. Findings from interviews and ration modeling program results regarding the inclusion, performance attributes, barriers, and relative pricing into a species-specific diet are highlighted later in the report.

AURI provided the following nutritional profile for mechanically pressed HSM (Table 2) to nutritionists to model and hypothesize which species would be the best targets and which price points and inclusion rates would be viable against other commonly used feed ingredients. The HSM is from a mechanically pressed system that was analyzed by AURI. Different processing methods and varieties will produce different qualities of meal. The valuation and comparable data points are based on the quality of this mechanically pressed HSM and the general market conditions from the summer of 2025.

Analysis		HSM		Amino Acid	HSM W/W% (DM)
Moisture	%	8.5		Aspartic Acid	3.40
Dry matter	%	91.5		Threonine	1.02
Crude Protein	% DM	37		Serine	1.68
Fat	% DM	14.8		Glutamic Acid	5.82
Fiber	% DM	26.1		Proline	1.31
Ash	% DM	8.02		Glycine	1.65
Sulfur (total)	% DM	0.37		Alanine	1.44
Phosphorus (total)	% DM	1.84		Cystine	0.55
Potassium (total)	% DM	1.40		Valine	1.28
Magnesium (total)	% DM	0.74		Methionine	0.79
Calcium (total)	% DM	0.18		Isoleucine	1.17
Sodium (total)	%DM	<0.01		Leucine	1.88
Iron (total)	ppm (DM)	236		Tyrosine	1.05
Manganese (total)	ppm (DM)	230		Phenylalanine	1.39
Copper (total)	ppm (DM)	23		Lysine	1.26
Zinc (total)	ppm (DM)	130		Histidine	0.87
Net Energy (Lactation)	Mcal/lbs	0.88		Arginine	4.01
Metabolizable Energy	Mcal/lbs	1.49		Tryptophan	0.48
Digestible Energy	Mcal/lbs	1.69			

Table 2: *Analytical Data for Mechanical Pressed HSM (AURI, 2025)*

The following sections (poultry, swine, cattle) are based on the quality factors (Table 2), 2025 pricing levels for soybean meal, and HSM's book value without a digestibility coefficient incorporated for energy, nutrition, and fiber, as one was not available to incorporate. This section provides a snapshot of potential valuations by species based on diet requirements and market conditions at the time.

Poultry

Overview. Multiple studies have demonstrated the safety of HSM in broiler and laying hen diets. Studies have found that the inclusion of hemp seed (up to 30%) and hemp oil (up to 9%) can maintain healthy liver and organ function, and that the levels of metabolites and electrolytes in blood plasma were not affected (Neijat, Gakhar, Neufeld, & House, 2014). Research that assessed broiler diets containing up to 24% HSM, 18% hemp seed, and 9% hemp oil reported finding no detrimental effect on broiler performance (Rasool, 2018).

Testing tissues and products for cannabinoid presence is occurring as part of feeding trials and needs to continue to fill this information gap. The Hemp Feed Coalition tested for cannabinoid residues in eggs, blood, breast meat, abdominal fat, liver, kidney and spleen, with residue findings being below laboratory detectable levels (Hemp Feed Coalition, 2026).

New standards and testing applications are being developed by commercial laboratories and academic institutions and MBOLD is supporting cannabinoid testing on turkeys fed industrial HSM.

Laying Hens. Studies of HSM in the diets of laying hens have shown promising results, indicating it may provide a useful, protein-rich feed source that maintains animal performance parameters (Silversides & Lefrançois, 2005). Laying hen diets containing HSM up to 20% (Silversides & Lefrançois, 2005), hemp seed oil up to 9% (Skřivan, Englmaierova, Vıt, & Skřivanova, 2019), and hemp seed up to 20% did not negatively affect performance in controlled studies with field data suggesting potential improvements in feed conversion, egg weight, and livability. Additionally, unpublished studies have shown HSM inclusion can be safely fed at up to 30% levels with no adverse effects on nutrition, health, or performance (Hemp Feed Coalition, 2026).

The approved AAFCO definition for HSM is for the inclusion of mechanically extracted HSM at up to 20% in laying hen diets.

Turkeys. Turkeys may be a promising commercialization pathway for multiple reasons. During nutritionist interviews conducted by AURI, one researcher noted improved digestibility for HSM over the base diet (soybean meal), a potential benefit of anti-inflammatory response, and improved health and growth performance. A follow-on study would be needed to illustrate why this is occurring and to target its use in diets accordingly.

Value. To incorporate the mechanically pressed HSM quality in this study into poultry diets, it would need to be discounted relative to soybean meal (SBM) by approximately 60% for turkeys, 40% for laying hens, and 75% for broiler diets. These valuations are based on formulation economics against the stated quality profile and do not incorporate other potential positive quality attributes of HSM inclusion in poultry diets.

Swine

Overview. The inclusion of hemp products in swine diets is still in its early stages of research and development. Most studies have investigated the use of hemp products in diets for lactating sows and piglets. Nutritionists interviewed during this study indicated that baby pigs represent the most promising opportunity for HSM. However, concerns exist about the safety of hemp products in swine, and the higher fat content in mechanically pressed HSM is a concern for incorporating into swine diets.

Sows. Research indicated that feeding sows hemp-derived products may have positive impacts on the immune systems of piglets during the pre-weaning period (Mohamed & House, 2024, p. 393). Other researchers have noted that the polyunsaturated fatty acids in hemp seed oil influence the composition of sow plasma, colostrum, and mature milk, and that the potential benefits to piglets are an area deserving of further study (Vodolazska & Lauridsen, 2020). Researchers assessing diets for lactating sows found that adding 5% hemp seed to their feed positively impacted the growth performance of piglets (Habeanu, et al., 2018). Similar results were found by researchers who included 5% hemp seed oil, but they observed a reduction in sow weight during pregnancy (Vodolazska & Lauridsen, 2020). Another study did not observe weight loss in sows when using feeds with 1.6% hemp seed oil, which may suggest that lower levels of hemp seed oil could be recommended for lactating sows and, subsequently, piglet performance (Idriceanu, Lefter, Gheorghe, Habeanu, & Dragotoiu, 2021).

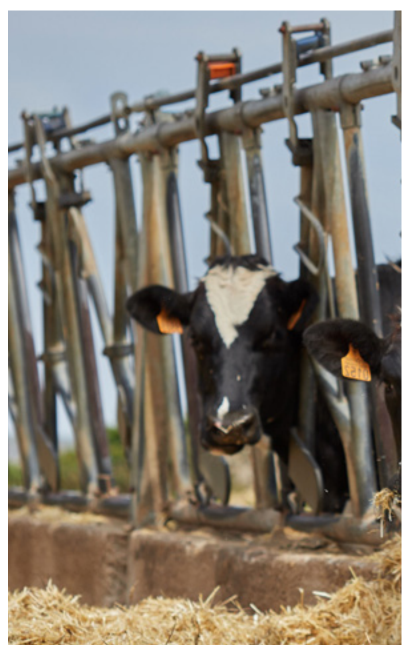
Value. To incorporate the mechanically pressed HSM quality of this study into a swine diet, it would need to be discounted relative to SBM – by approximately 45% for finishing diets.

Cattle

Dairy. The use of HSM in dairy cow diets has been investigated and inclusion rates of 20% HSM in feed found "decreased growth performance" compared to cattle fed DDGS (Distillers Dried Grains with Solubles).

Beef. Researchers believe HSM could be a viable feed source for beef cattle, noting that "diets containing HSM are readily consumed by finishing heifers" and that additional research is needed to "better understand how hemp seed cake can best be utilized in cattle diets" (Winders, et al., 2022). Members of the same research group also found low levels of cannabinoids residue in cattle fed HSM in the fat and below detectable levels in muscle (Smith, et al., 2023). The levels detected would make it "very difficult for a human to consume enough fat from cattle fed with HSM to exceed regulatory guidelines for dietary THC exposure" (USDA-ARS, 2023).

Value. To incorporate the mechanically pressed HSM quality of this study into a cattle diet, it would likely need to be discounted relative to SBM – by approximately 75% for dairy diets and 50% for beef cattle diets.



Summary

Research to date indicates HSM can be incorporated into diets for multiple livestock species when priced at varying discount levels to soybean meal. For mechanically pressed HSM, the required discount relative to soybean meal is substantial across most species due to its high fiber content, lower lysine levels, and residual fat.

Additional research is needed to understand how solvent-extracted, low-fat HSM would influence species-specific valuations and inclusion rates.

Laying hens currently represent the only species with regulatory approval for HSM inclusion, and they show one of the strongest economic fits based on modeled valuations. Turkey studies have shown some promising signals as well, including anti-inflammatory benefits and improved efficiency.

From a value recovery standpoint for the mechanically pressed HSM used in this study, discounts range from roughly 40% to 75% relative to soybean meal, with the most favorable returns occurring in laying hen diets.

SUSTAINABILITY AND RELATIVE GHG EMISSIONS FROM GREEN FEEDS

Carbon intensity (CI) and greenhouse gas (GHG) emissions are the metrics by which most sustainability goals are reported and measured against. LEIF LLC conducted a literature review of current CI data comparing industrial hemp production to conventional row crops like corn, soy, as well as winter camelina and alfalfa. Industrial hemp showed the greatest variability among the evaluated crops, largely dependent on whether post-harvest biomass was left on the field or removed. Under certain circumstances, hemp was the only evaluated crop with carbon-negative production potential.

If the biomass is left on the field post-harvest or utilized in a product, such as a building material, with a reference service life of 100 years, industrial hemp shows considerable average emissions reductions[9] (-1.77 kg CO2e[10]/kg seed) due to its ability to sequester carbon, whereas if biomass is removed post-harvest, emissions are more appreciable (2.60 kg CO2e/kg seed). For comparison, the Midwest mean[11] emission intensity scores for the other crops in this life cycle assessment (LCA) review were 0.42 kg CO2e/kg grain (corn), 0.41 kg CO2e/kg soybean (soy), 0.40 kg CO2e/kg seed (winter camelina), and 0.48 kg CO2e/kg hay (alfalfa) (Figure 2).

[9] Based on a global production "mean" emission.

[10] CO2e refers to carbon dioxide equivalent, "a metric used to compare the emissions from various greenhouse gases based on their global warming potential (GWP). GWP is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon relative to carbon dioxide. It is a way of normalizing the fact that different GHGs have different physical properties. CO2e is expressed as a function of the amount of a gas, its GWP, and the time period considered. It allows for a common basis for comparing the potential future impact on global warming of emissions of different gases" (Arbor, 2025).

[11] It is important to note that available literature studies for industrial hemp were based on crop production in Europe and Canada, where growing conditions are less comparable to that of the corn and soy analogue reports in this study (grown under in typical Midwest growing conditions). Therefore, conducting a Midwest-based industrial hemp study to generate original crop production data will serve as a more accurate basis of comparison to the emissions of intensities of other crops in this region.

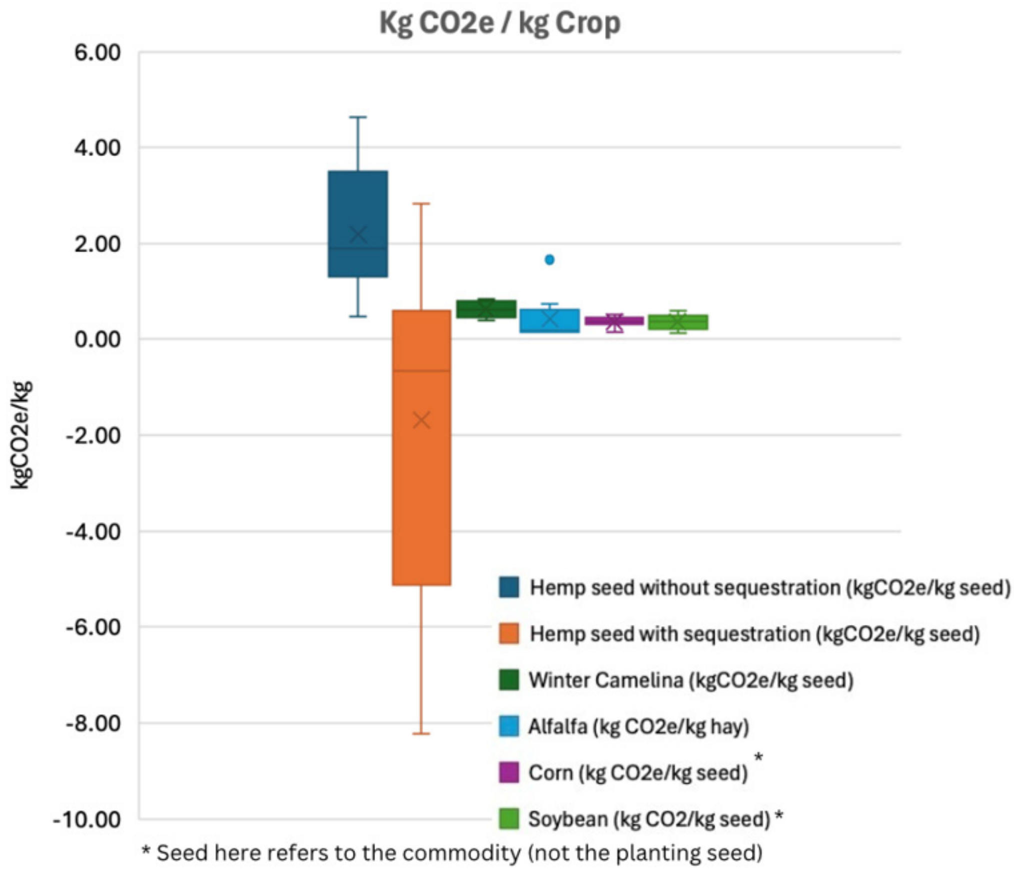


Figure 2: *Emission Intensity Across Crops (LEIF LLC, 2025)*

INTERPLAY WITH OTHER MARKETS

Industrial hemp is a uniquely versatile crop with multiple market-pull opportunities across oil, fiber, and environmental value streams. Hemp seed contains roughly 30% oil, which can be utilized in both food or biofuels markets. Growing demand for sustainable aviation fuel (SAF) and renewable diesel (RD) could provide a strong pull if hemp oil is approved as an eligible feedstock to meet renewable fuel market demand.

The crop's biomass also supports a wide range of fiber and material applications. Hemp fiber has long been used in textiles and is increasingly of interest for biobased building products. Emerging markets for fiber and hurd biomass include biocomposites, fiber applications, hempcrete, acoustic panels, insulation, drywall compounds, and other sustainable building products.

Industrial hemp's potential to achieve a negative carbon intensity score further enhances its strategic value. If validated, this characteristic could unlock policy incentives and help meet corporate and government-level environmental goals.

Within this broader market context, developing a stable and scalable outlet for HSM in animal feed is essential. Because HSM represents a major portion of the seed's mass after oil extraction, feed markets will play a critical role in enabling full crop utilization and improving overall value-chain and producer economics.

CONCLUSIONS AND RECOMMENDATIONS FOR HSM

HSM is an emerging feed ingredient, with regulatory approval currently limited to laying hens. Additional species-specific trials are underway and broader approvals and market adoption will require more comprehensive safety and performance data to confirm its impacts on animal growth, health, and nutrient utilization.

HSM has a strong nutritional profile, including relatively high protein content and essential fatty acids (linolenic) levels, while also having a favorable omega-6 to omega-3 fatty acid ratio. However, its lysine deficiency and the potential presence of trace contaminants remain important considerations. Ensuring cannabinoids are not present in appreciable levels in consumer-facing products is also a critical hurdle that needs to be overcome to gain broader market acceptance.

Nutritionists and industry participants were generally familiar with HSM and indicated inclusion levels up to 20% are feasible under the right conditions. While they raised valid concerns about its nutritional limitations and regulatory uncertainties, they expressed interest in its potential as a more sustainable feed ingredient. Ration-balancing software indicated the mechanically pressed HSM quality used for this study would need to be priced at a significant discount to soybean meal across most species, with the most favorable valuation occurring for laying hens under 2025 market conditions.

Most life cycle assessments for hemp have been conducted outside of the United States, and U.S.-specific analyses are needed to narrow the range of carbon-intensity estimates to illustrate its potential as a sustainable feed ingredient. Hemp's potential to achieve a negative carbon-intensity score positions it as a promising feed ingredient for industries and entities seeking sustainable feed alternatives.

Finally, continued advancement in hemp genetics, particularly through hybridization, could substantially improve grain yields, consistency, and overall economic competitiveness. These improvements, combined with additional regulatory approvals, would accelerate adoption by farmers and value-chain partners.

Recommendations

Several informational gaps remain, and addressing these will be essential to building confidence in its broader use.

- Conduct an Upper Midwest life cycle assessment to fill informational gaps on its footprint to be a more sustainable feed ingredient and potential to achieve a negative CI score.
- Conduct research to understand the quality differences between mechanically pressed and solvent-extracted HSM to assess market opportunities and valuations for solvent-extracted HSM.
- Support additional feeding trials related to safety and optimization; broilers and turkeys should be prioritized based on past research findings.
- Support additional understanding of the potential for cannabinoid accumulation and/or pass-through across species and into meat, milk, or eggs is essential to assessing the regulatory challenge associated with using HSM.
- Expanding the AAFCO definition and achieving regulatory approvals will be critical next steps for expanding HSM utilization beyond laying hens. Supporting additional safety and performance studies across more species will be important to accelerate the commercial opportunity for HSM.

Nutritionists and industry participants were generally familiar with HSM and indicated inclusion levels up to 20% are feasible under the right conditions. While they raised valid concerns about its nutritional limitations and regulatory uncertainties, they expressed interest in its potential as a more sustainable feed ingredient.

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