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Potential for Using Hemp as Livestock Feed

This report provides an overview of the state of literature on hemp (*Cannabis sativa* L.) with a focus on its potential for use as livestock feed. Literature emanating from U.S. experiences is limited because federal and state governments have only recently relaxed regulations on hemp cultivation and production. This report offers examples of how hemp is currently being used as livestock feed, with a recognition of the limited scientific consensus on its economic and nutritional benefits. Also provided is an overview of the recent regulatory developments at the federal level and in the State of Vermont. The report concludes with a summary of the state of knowledge of hemp as livestock feed and the potential for future developments in the area.

Overview of Hemp

Hemp is an “emblematic example of a multi-purpose crop.”¹ Originating in Central Asia, it was first used as food, textile fiber, and in folk medicine.² More recently, hemp has attracted the interests of both the construction and pharmaceutical sectors.³ It is now repurposed for a diverse array of uses including agricultural products, recycling, automotive parts, furniture, food and beverages, paper, construction, and personal care.⁴ Despite this interest, more research is required to understand the basic biology and safety of specific uses for hemp.⁵

The 2018 Farm Bill removed hemp from the Controlled Substances Act – considering it an agricultural product – and expanded the definition of industrial hemp from the 2014 Farm Bill.⁶ It also gave more autonomy to states to regulate hemp cultivation. Although states have addressed hemp differently, at

¹ Christelle M. Andre, Jean-Francois Hausman, and Gea Guerriero, “*Cannabis Sativa*: The Plant of the Thousand and One Molecules,” *Frontiers in Plant Science* 7, no. 19 (February 2016) doi: 10.3389/fpls.2016.00019

² Andre et al., “*Cannabis Sativa*: The Plant of the Thousand and One Molecules.”

³ Matt A.V. Chaban, Cannabis Construction: Entrepreneurs Using Hemp for Home-Building, *The New York Times*, July 6, 2015 <https://www.nytimes.com/2015/07/07/nyregion/cannabis-construction-entrepreneurs-use-hemp-in-home-building.html> ; R.L. Hilderbrand, “Hemp & Cannabidiol: What is a Medicine?” *Missouri Medicine* 115, no. 4 (July-August 2018).

⁴ Cornell Cooperative Extension, “Industrial Hemp: From Seed to Market,” May 2017, <http://csetompkins.org/resources/industrial-hemp-from-seed-to-market>.

⁵ Craig Schluttenhoffer and Ling Yuan, “Challenges towards Revitalizing Hemp: A Multifaceted Crop” (Opinion) *Trends in Plant Science* 22, no. 11 (November 2017)

<https://www.sciencedirect.com/science/article/pii/S1360138517301772>.

⁶ National Conference of State Legislatures, “State Industrial Hemp Statutes,” February 1, 2019.

<http://www.ncsl.org/research/agriculture-and-rural-development/state-industrial-hemp-statutes.aspx#state>

least 41 states have enacted legislation that creates hemp cultivation programs.⁷ It is estimated that the commercial market value of hemp in North America is \$400 million, and it is growing by 10% each year.⁸

Regulation of Hemp

Federal Regulation

As mentioned above, the 2018 Farm Bill changed hemp regulation and policy dramatically. It removed hemp from the Controlled Substances Act and classified it as an agricultural product.⁹ The bill also allows states to apply to be the primary regulatory authority over hemp, provided that they meet certain federal standards.¹⁰ These standards include basic testing requirements and methods to dispose of plants with a high THC content. Due to this major definitional and regulatory change, federal agencies and agricultural organizations have scrambled to change their position on the potential of hemp. Two major federal agencies which have begun this change are the Association of American Feed Control Officials and the Food and Drug Administration.

The Association of American Feed Control Officials (AAFCO) is an organization that provides guidance to government agencies tasked with regulating the sale and distribution of animal feed.¹¹ In 2017, AAFCO issued a report with guidelines relating to hemp in animal feed.¹² The report states, “[o]ne thing has become clear as we have had discussions with the hemp industry, materials and products that are CBD infused need to be treated as drugs. There is no nutritional intended use for this compound.”¹³ This report came out prior to the definition change in the 2018 farm bill. Since then, AAFCO has held meetings and tasked employees to conduct research on the viability of hemp in animal feed.

The Food and Drug Administration (FDA) is a federal agency in charge of regulating food in the United States. While the 2018 Farm Bill removed hemp from the Controlled Substances Act, it did not exempt it from FDA regulation under the Food, Drug and Cosmetic Act.¹⁴ Importantly, this act makes it unlawful to enter CBD or THC containing products into interstate commerce.¹⁵ Essentially, this means that states that grow hemp must keep their products within state boundaries. Another important development by the FDA was the issuance of three Generally Recognized as Safe (GRAS) reports. These reports confirm

⁷ National Conference of State Legislatures, “State Industrial Hemp Statutes.”

⁸ “Industrial Hemp,” Northwest Crops and Soils Program, The University of Vermont, accessed April 30, 2019, <https://www.uvm.edu/extension/nwcrops/crops/industrial-hemp>.

⁹ National Conference of State Legislatures, “State Industrial Hemp Statutes.”

¹⁰ National Conference of State Legislatures, “State Industrial Hemp Statutes.”

¹¹ Association of American Feed Control Officials, “Welcome to AAFCO,” accessed April 29, 2019, <https://www.aafco.org/>.

¹² Association of American Feed Control Officials, “AAFCO Guidelines on Hemp in Animal Food,” March, 2017, https://www.aafco.org/Portals/0/SiteContent/Announcements/AAFCO_Guidelines_on_Hemp_in_Animal_Food_2.pdf?v2.

¹³ Association of American Feed Control Officials, “AAFCO Guidelines on Hemp in Animal Food.”

¹⁴ Scott Gottlieb, *Statement from FDA Commissioner Scott Gottlieb, M.D., on signing of the Agriculture Improvement Act and the agency’s regulation of products containing cannabis and cannabis-derived compounds*, December 20, 2018, <https://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-signing-agriculture-improvement-act-and-agencys>.

¹⁵ Food, Drug and Cosmetics Act, 21 U.S.C. § 301(II).

the safety of three hemp by-products – hulled hemp seeds, hemp seed protein, and hemp seed oil. However, GRAS reports do not allow these products to be exchanged via interstate commerce.¹⁶

Vermont Regulation

In Vermont, hemp can only legally be grown if the grower is registered with the Vermont Agency of Agriculture, Food and Markets and is in accordance with federal pilot program regulations.¹⁷ Figure 1 shows the number of registered hemp growers and the acreage being used to grow hemp in each county. There is no prohibition against deliberately adding CBD and other CBD products to animal feed in Vermont. This includes the use of hemp.¹⁸

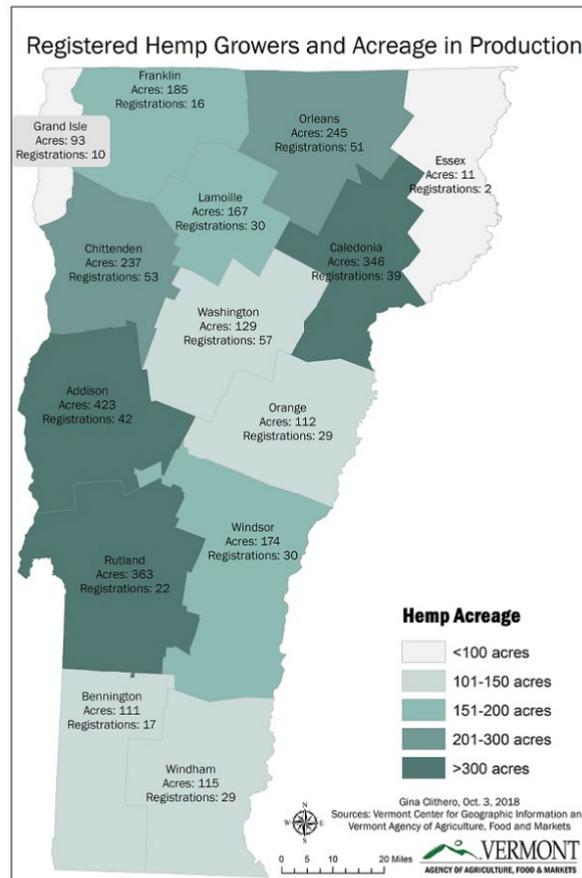


Figure 1: Registered Hemp Growers and Acreage in Production

Source: “Hemp Program,” Vermont Agency of Agriculture, Food, and Markets, accessed April 25, 2019, <https://agriculture.vermont.gov/public-health-agricultural-resource-management-division/hemp-program>.

¹⁶ Dennis M. Keefe in a letter to Marc C. Sanchez, Re: *GRAS Notice No. GRN 000771*, December 20, 2018, <https://www.fda.gov/media/119428/download>.

¹⁷ “Hemp Program,” Vermont Agency of Agriculture, Food, and Markets, accessed April 25, 2019, <https://agriculture.vermont.gov/public-health-agricultural-resource-management-division/hemp-program>.

¹⁸ “Hemp, CBD, Cannabinoids as ingredients in foods and feeds in Vermont,” Vermont Agency of Agriculture, Food, and Markets, accessed April 26, 2019, <https://agriculture.vermont.gov/sites/agriculture/files/documents/PHARM/hemp/Hemp%20in%20Food%20and%20Feed%20Vermont%20.pdf>.

Hemp as Livestock Feed

With the growing acceptance of hemp cultivation in the United States, there has been speculation over whether hemp may be an acceptable source of feed for livestock. There are various forms of feed that may be derived from hemp plants: 1) hemp seed; 2) hemp seed meal/cake; 3) hemp seed oil; 4) whole hemp plant.¹⁹

Some forms of hemp feed have relatively high amounts of fiber, indicating that it may be a valuable source of protein for livestock.²⁰ Table 2 shows the high protein content of hemp seed as compared to other major food sources. A study conducted on agriculture and agri-food observed the effect hemp seed had on fatty acids of feedlot cattle. The study found that inclusion of hemp seed in the diet was correlated with an increase of conjugated linoleic acid (CLA) and n-3 fatty acids without negatively affecting cattle performance. Scientists of this study observed a notable increase of fatty acid composition in cattle when 14% hemp seed was added to their diet compared to when there was 0% of hemp seed in the feed.²¹ Table 2 shows the fatty acid composition of steers that were fed barley based diets containing 0, 9, and 14% of hemp seed. It was evident from the findings that the hemp seed resulted in a notable increase in C 18 fatty acids. The study concluded that hemp seed could be used as a valuable source of energy and protein in the diet on feedlot cattle.²²

Little research has been conducted on the safety of hemp feed for cattle consumption and the impacts for humans who consume cattle products. The main concern over hemp as feed is the presence of THC and the transfer of that to the animal. The limited THC that is present in hemp seed is mostly found on the outside of seeds. Generally, this is due to contamination from the leaves of hemp plants.²³ No studies could be found related to the safety of hemp as food for cattle. However, there are several reports of accidental animal poisoning from ingesting cannabis material. These incidents have occurred specifically with dogs, but do not provide evidence to establish a dose-effect relationship.²⁴ There is also evidence that in the case of accidental poisoning animals may make a full recovery properly treated.²⁵ Based on a study conducted by the FEEDAP Panel on the transfer of THC from whole hemp and hemp seed-fed cows' milk to humans, there would be small amounts of THC transferred from the product to

¹⁹ European Food Safety Authority, "Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed," *European Food Safety Authority Journal* 9 (3) 2011, <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2011.2011>.

²⁰ A. F. Mustafa, J. J. McKinnon, and D. A. Christensen, Department of Animal and Poultry Science "The nutritive value of hemp meal for ruminants," 1998, <https://www.nrcresearchpress.com/doi/pdf/10.4141/A98-031>.

²¹ D. J. Gibb, M. A. Shah, P. S. Mir, T. A. McAllister, *Canadian Journal of Animal Science*, "Effect of full-fat hemp seed on performance and tissue fatty acids of feedlot cattle," 2005 <https://www.nrcresearchpress.com/doi/pdfplus/10.4141/A04-078>.

²² D. J. Gibb, M. A. Shah, P. S. Mir, T. A. McAllister, *Canadian Journal of Animal Science*, "Effect of full-fat hemp seed on performance and tissue fatty acids of feedlot cattle," 2005 <https://www.nrcresearchpress.com/doi/pdfplus/10.4141/A04-078>.

²³ European Food Safety Authority, 2011, "Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed," 2,

²⁴ European Food Safety Authority, 2011, "Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed," 12

²⁵ European Food Safety Authority, 2011, "Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed," 12

the consumer.²⁶ Table 3 shows the THC transfer from these cows to adults and children. The FEEDAP Panel concluded that given these safety concerns over THC exposure, there was no option for further use of whole hemp plant-feed materials for feeding dairy cattle.²⁷

Table 6. Fatty acid composition (g 100 g⁻¹ total FA) of pars costalis diaphragmatic (PCD) samples from steers fed barley-based finishing diets containing 0, 9 or 14% full-fat hemp seed

	Treatment (dietary hemp seed)			SEM	P value ²	P value (linear) ^y	0 vs. 9 & 14 ^x
	0%	9%	14%				
C14:0	3.05	3.11	3.29	0.14	0.44	0.21	0.36
C14:1 <i>cis</i>	0.58	0.56	0.51	0.04	0.49	0.24	0.42
C16:0	25.59	25.11	25.08	0.44	0.65	0.45	0.35
C16:1 <i>trans</i>	0.30	0.30	0.29	0.01	0.88	0.65	0.83
C16:1 <i>cis</i>	3.28 ^a	2.88 ^b	2.75 ^b	0.08	<0.001	<0.001	<0.001
C17:0	1.82	1.69	1.75	0.05	0.16	0.46	0.09
C17:1	1.13 ^a	0.92 ^b	0.89 ^b	0.04	<0.001	<0.001	<0.001
C18:0	14.62 ^b	16.90 ^a	18.27 ^a	0.51	<0.001	<0.001	<0.001
C18:1 <i>trans-9</i>	2.23 ^b	3.32 ^a	4.19 ^a	0.35	<0.001	<0.001	0.008
C18:1 <i>cis-9</i>	42.83 ^a	39.64 ^b	37.78 ^b	0.90	<0.001	<0.001	<0.001
C18:2 <i>trans, trans</i>	0.15 ^c	0.31 ^b	0.37 ^a	0.01	<0.001	<0.001	<0.001
C18:2 <i>cis, cis</i>	2.69	3.08	2.67	0.17	0.11	0.99	0.19
C18:3	0.39 ^b	0.60 ^a	0.59 ^a	0.03	<0.001	<0.001	<0.001
C20:0	0.13	0.12	0.13	0.02	0.94	0.82	0.99
C20:1	0.21 ^a	0.17 ^b	0.16 ^b	0.01	<0.01	0.009	0.002
C20:4	0.26	0.35	0.29	0.04	0.35	0.85	0.29
C22:5	0.08	0.11	0.09	0.01	0.16	0.75	0.15
CLA <i>cis-9, trans-11</i>	0.21 ^b	0.27 ^{ab}	0.28 ^a	0.01	<0.001	<0.001	<0.001
CLA <i>trans-10, cis-12</i>	0.00	0.00	0.01	0.00	0.49	0.25	0.46
Saturated	45.76 ^b	47.47 ^{ab}	49.11 ^a	0.71	<0.01	0.002	0.005
Unsaturated	54.24 ^a	52.52 ^{ab}	50.88 ^b	0.71	<0.01	0.002	0.005
Saturated/Unsaturated	0.85 ^b	0.91 ^{ab}	0.97 ^a	0.03	0.008	0.002	0.007

¹Significance of differences between treatments.

²Significance of linear effect of hemp level in diets.

³Significance of effect of hemp seed in diet compared with feeding no hemp seed.

^{a-c} Within a row, values followed by different letters differ ($P < 0.05$).

Table 1: Fatty acid composition from steers fed barley-based finishing diets containing 0,9, or 14% full fat hemp seed

Source: European Food Safety Authority, "Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed," *European Food Safety Authority Journal* 9, no. 3 (2011), <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2011.2011>.

²⁶ European Food Safety Authority, 2011, 2 "Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed," 14.

²⁷ European Food Safety Authority, 2011, 2 "Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed," 15.

Table 3. Typical protein content (%) of each food is given directly below the name

Amino acid	Potato (2%)	Wheat (14%)	Maize (11%)	Rice (9%)	Soy bean (32%)	Hempseed (25%)	Rapeseed (23%)	Egg white (13%)	Whey powder (13%)
Alanine	0.09	0.50	0.72	0.56	1.39	1.28	1.05	0.83	0.61
Arginine	0.10	0.61	0.40	0.62	2.14	3.10	1.49	0.68	0.39
Aspartic acid	0.34	0.69	0.60	0.86	3.62	2.78	1.82	1.23	1.49
Cystine	0.02	0.28	0.15	0.10	0.54	0.41	0.39	0.29	0.17
Glutamic acid	0.37	4.00	1.80	1.68	5.89	4.57	4.41	1.67	2.40
Glycine	0.10	0.71	0.35	0.47	1.29	1.14	1.28	0.50	0.29
Histidine*	0.03	0.27	0.26	0.19	0.76	0.71	0.72	0.28	0.29
Isoleucine*	0.08	0.53	0.35	0.35	1.62	0.98	1.00	0.74	0.85
Leucine*	0.11	0.90	1.19	0.71	2.58	1.72	1.80	1.08	1.40
Lysine*	0.10	0.37	0.33	0.31	1.73	1.03	1.49	0.74	1.15
Methionine*	0.02	0.22	0.18	0.17	0.53	0.58	0.46	0.47	0.23
Phenylalanine*	0.08	0.63	0.46	0.43	1.78	1.17	1.05	0.76	0.49
Proline	0.09	1.53	0.85	0.40	1.65	1.15	1.59	0.50	0.43
Serine	0.08	0.70	0.47	0.48	1.54	1.27	1.10	0.92	0.64
Threonine*	0.07	0.42	0.34	0.34	1.35	0.88	1.13	0.58	1.02
Tryptophan*	0.02	0.51	0.04	0.09	0.41	0.20	0.31	0.20	0.25
Tyrosine	0.06	0.40	0.36	0.33	1.14	0.86	0.69	0.46	0.47
Valine*	0.10	0.61	0.46	0.51	1.60	1.28	1.26	0.98	0.91

Individual amino acid values for each food is given in grams per 100 g. Essential amino acids are indicated by an asterisk (*).

Table 2: Protein Content (%) of Each Food

Source: J.C. Callaway, "Hempseed as a nutritional resource: An overview," *Euphytica* 140, no. 1 (2004): 65-72, <https://doi.org/10.1007/s10681-004-4811-6>, 15.

Table 2: Exposure of adults and children (one to three years of age) to THC via milk from dairy cows ingesting different levels of whole hemp plant-derived feed materials with 0.2 % THC (maximum legal content) and with different milk yields

	THC intake (mg)					
	Adults from 2.0 L milk			Children from 1.5 L milk		
Milk yield (L/day)	15	25	35	15	25	35
Cow daily intake (kg DM)						
1.5	0.60	0.36	0.26	0.45	0.27	0.19
1.0	0.40	0.24	0.17	0.30	0.18	0.13
0.5	0.20	0.12	0.09	0.15	0.09	0.06

Table 3: Exposure of adults and children (one to three years of age) to THC via milk from dairy cows ingesting different levels of hemp seed-derived feed materials with 0.0012 % THC and with different milk yields

	THC intake (mg)					
	Adults from 2.0 L milk			Children from 1.5 L milk		
Milk yield (L/day)	15	25	35	15	25	35
Cow daily intake (kg DM)						
1.5	0.0036	0.0022	0.0015	0.0027	0.0016	0.0012
1.0	0.0024	0.0014	0.0010	0.0018	0.0011	0.0008
0.5	0.0012	0.0007	0.0005	0.0009	0.0005	0.0004

Table 3: Exposure to adults and children to THC via milk from dairy cows ingesting different levels of whole hemp plant-derived materials with .2% THC

Source: European Food Safety Authority, “Scientific Opinion on the safety of hemp (*Cannabis genus*) for use as animal feed,” *European Food Safety Authority Journal* 9 (3) 2011, <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2011.2011>.

Colorado Feasibility Study

In 2017, the Colorado State Legislature passed a bill which created a study group to assess the feasibility of including hemp products in animal feed.²⁸ In December 2017, the Colorado Department of Agriculture released its report to the legislature.²⁹ The report highlighted six stakeholder conclusions and a legislative recommendation for how to best proceed with the regulation of hemp. This included assessing whether hemp is a plausible source of animal feed. Since the report was conducted before the

²⁸ Colorado General Assembly, “S17-109: Industrial Hemp Animal Feed,” 2017, accessed April 25, 2019, <https://leg.colorado.gov/bills/sb17-109>.

²⁹ Colorado Department of Agriculture, *A Stakeholder Review of the Feasibility of Industrial Hemp By-Products as Animal Feed Ingredients*, December 2017, <https://www.colorado.gov/pacific/sites/default/files/CDA%20Report%20on%20Hemp%20in%20Animal%20Feed%2012-29-2017.pdf>.

changes in the 2018 Farm Bill, some of its findings are outdated. It stresses the importance of conducting further research on the health and safety of hemp. The goals and recommendation of the report are as follows:

Goal 1: Prioritize federal approval

Goal 2: Focus on whole hemp seed and hemp seed by-products

Goal 3: Conduct research into the economic viability

Goal 4: Target submission of a food additive petition

Goal 5: Include an experienced consultant in a collaborative effort

Goal 6: Execute a S.A.F.E petition process

S- Start early discussions with the FDA-CVM (Food & Drug Administration Center for Veterinary Medicine)

A- Assemble and assess existing research

F- Fill in any gaps with additional research

E- Execute a targeted petition that identifies specific species and intended uses

Recommendation: Support research and submission of a food additive petition to determine the safety and utility of hemp seed products as animal feed ingredients.

Conclusion

As has been repeatedly mentioned throughout this report, there is a lack of scientific research on the potential of hemp as livestock feed. More research on the nutritional, economic, and biological value of hemp is needed. European studies have demonstrated the viability of using hempseed as a component in livestock feed, mostly for its high protein content.³⁰ However, there are concerns among scientists that the use of hemp as animal feed may result in the transmission of THC to the food products of hemp-fed livestock. As U.S. federal regulation has loosened, it is likely that more states will pursue research and seek to take advantage of the multi-purpose uses of hemp. There will need to be further research regarding the safety concerns of hemp use as commercial animal feed.

This report was completed on May 8, 2019, by Katherine Cutler, Zach Handelman and Sebastian Wu under the supervision of VLRS Research Assistant Eric Tucker and VLRS Director, Professor Anthony “Jack” Gierzynski in response to a request from Rep. Charen Fegard.

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³⁰ Cherney and Small, “Industrial Hemp in North America,” 7.