HEMP FEED
Industry • Academia • Regulators
WORKSHOP

WHITE PAPER

Identification of Research Priorities for the Use of Hemp Byproducts as Feed Ingredients for Livestock and Animals

Results from a two-day workshop was held October 26-27, 2022 at the CH_2M HILL Alumni Center, Oregon State University, Corvallis, Oregon.

The workshop was supported by USDA National Institute of Food and Agriculture Grant# 2022-67015-37980.

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Summary

In October 2022, Oregon State University and the Hemp Feed Association convened a group of researchers, regulators, and industry representatives for a workshop supported by the Institute of Food and Agriculture (NIFA) to identify research priorities and data needed by regulators for the legalization of hemp and its byproducts as an animal feed ingredient. There were 81 participants, with 31 in-person and 50 via virtual links. The presentations by industry partners revealed the need for open markets in the animal feed sector to support true growth for the hemp industry. Also identified as an important challenge was the long timeline by regulators to review applications to move the legalization of hemp byproducts as feed ingredients forward. The hemp industry in Canada also has similar challenges, with even longer turnaround and more complicated applications than in the United States (U.S.). Both Canada and U.S. hemp industry partners agreed that more research on hemp byproducts feeding to animals is needed. The researchers provided updates on the status of experiments conducted in the U.S. and Canada where hemp byproducts were fed to sheep, goats, cattle, horses, swine, rabbits, and dogs, with hemp byproducts tested, including spent hemp biomass after cannabinoid extraction, hempseed cake, hemp flower, and cannabinoids, especially cannabidiol (CBD). Various cannabinoids were detected in tissues of animals fed spent hemp biomass. Very few residuals were detected for animals fed hempseed cake, and only in some of the tissues involved in clearance from the metabolic system (e.g., kidney). No cannabinoids were detected in the egg of hens fed hempseed cake. All the research conducted far to date did not find any detrimental effect of feeding hemp byproducts or CBD to animals. Measurement of cannabinoids still remains challenging, especially the consistency of protocols and detection among laboratories. There is also difficulty detecting cannabinoid amounts at the limit of detection required by the FDA. Initiatives are underway to address the above issues.

As research priorities, the ***Hemp Industry*** recognizes the importance of continued collaboration between regulators, researchers, and industry, especially considering the scarcity of research funding required to address this highest priority need for hemp producers and livestock and animal users. The hemp industry associations present at the workshop are committed to working together to address the above challenges. The ***regulators*** highlighted the need for a solid and data-driven argument to support the safety of products from animals fed hemp byproducts. They recognized the need to establish a tolerable dose intake (TDI) for cannabinoids, especially Δ9-tetrahydrocannabinol (THC), that can be established using animal models. The ***researchers*** agreed that establishing a TDI for cannabinoids is essential, but also identified as knowledge gaps proper inclusion amounts for each hemp byproduct, determination of metabolites of the various cannabinoids, paucity of data on the use of hemp byproducts with monogastric species, use of hemp byproducts as silage, and research on grazing hemp as priorities.

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Background

With the production of hemp grown for grain and cannabinoids, significant amounts of byproducts are generated after extracting the oil from seeds and cannabinoids from the biomass, mainly flowers, and leaves. The byproducts are hemp seed cake and spent hemp biomass (or pulp). Other co-products, including hemp hearts (dehulled seeds), vegetable oil produced from seeds, stalks (stover for silage), and cannabinoids, also show great potential for feed supplements. Research has shown that these co-products of the processed hemp materials offer highly nutritious options as feed ingredients for livestock and poultry, with great potential in other animal species as well. Currently, there are limited market opportunities for using by-products, so disposal as waste is at a great expense to hemp grain and biomass processing companies. Using by-products provides an opportunity for the animal industry because feed is a major cost characterized by great market volatility for livestock and poultry producers.

Studies mostly conducted in Europe and Canada indicated that various hemp by-products, including hemp seed cake or meal, are safe for animal use. Although both hemp and feed industries have great value and desire to introduce hemp products to market, those are not yet approved by the U.S. Food and Drug Administration - Center for Veterinary Medicine (**FDA-CVM**). The greatest concern raised by regulators for hemp products used as feed ingredients in food animal production is the potential presence of cannabinoid residuals, especially THC and cannabidiol (**CBD**), which are considered by the FDA as drugs. The Association of American Feed Control Officials (**AAFCO**) published a letter to express its position and call for action emphasizing the need for more research to ensure that hemp is safe for animals[1]. The letter from AAFCO has been endorsed by the American Veterinary Medical Association[2] and highlights the critical need for research to be conducted on the safety of hemp and its byproducts as feed ingredients for pets.

Statement of Need for the Workshop

The major limitation in the legalization of the use of hemp by-products as feed for animals is a lack of data that FDA-CVM can use to move forward with the approval process. Although data is generated by researchers working with livestock and poultry, many uncertainties exist regarding the data type needed for the regulators and the industry. This lack of clarity is a major limitation for researchers in planning research and seeking funding from industry and competitive federal research programs. The official letter from AAFCO and the subsequent endorsement by the AVMA provides further support for the need for research on the use of hemp and its byproduct as a feed ingredient.

There is a critical need to bring together representatives from the hemp industry and regulatory agencies and meet with researchers to identify research priorities and guidelines needed to aid with the legalization of hemp by-products as feed for livestock and poultry

[1] https://www.aafco.org/email/20210916/AAFCO_Hemp_Position_Release.pdf

[2] https://www.avma.org/news/organizations-warn-against-hemp-pet-food-livestock-feed?utm_source=delivra&utm_medium=email&utm_campaign=AVMA%20Vitals%20March%202022&utm_id=3563390&utm_term=Button&dlv-emuid=ed022776-71df-4151-bcf8-6ad2e64997df&dlv-mlid=3563390

Workshop Objective and Expected Outcomes

A two-day workshop was held at CH_2M HILL Alumni Center at Oregon State University (**OSU**), Corvallis, Oregon on October 26-27, 2022. The workshop was supported by USDA NIFA Grant# 2022-67015-37980.

The overarching goals of this workshop were to:

1. Bring together researchers, regulators, and hemp industry partners with knowledge of the use of hemp as feed for animals, to clearly articulate the current state of knowledge,
2. Foster a meaningful dialog among these experts, elucidating the fundamental scientific research needs and quality of measurements to cover the gap in knowledge to move forward with the legalization of the use of hemp by-products as a feed ingredient for livestock, poultry, and other potential species, and
3. Prepare a white paper for broad dissemination reporting the workshop findings and recommended paths forward.

The *workshop's objective* was to identify research priorities and data quality regulators need for the legalization of hemp and its byproducts as an animal feed ingredient.

Workshop Participation, Organization, and Activities

There were two types of attendance, in-person and online. The in-person attendance required a specific invitation and had a cost of registration of $50. The registration fee was waived for the invited speakers. The virtual attendance was held over Zoom and was open to everyone with a registration cost of $25. The workshop's registration and agenda were available via a specific website generated by the OSU. The website was also used to advertise the workshop on social media.

Workshop Participants.

There were 81 participants, with 31 in-person and 50 virtual participants. The subject matter expert speakers were:

Name	Organization	Role	Expertise
Archibeque, Shawn	Colorado State University	Professor	Use of hemp byproducts with beef cattle and sheep
Berhow, Mark	USDA ARS - Agricultural Research Service	Research chemist	Measurement of cannabinoids in plants
Bionaz, Massimo	Oregon State University	Associate Professor	Use of spent hemp biomass as feed for livestock
Bookout, Bill	National Animal Supplement Council	President, board chairman, and a founding member	Supplements for dog, cat, and horses
Buffington, Hunter	Element6 Dynamics	VP of Policy & Advocacy	Hemp policy and approval
Conway, Charlotte	FDA-CVM	Deputy Director	FDA regulations
Febles, Emily	U.S. Department of Agriculture	Hemp Marketing Specialist	NC State University research study on hempseed meal in poultry feed for broiler chickens.
Grajczyk, Terry	Canadian Hemp Trade Alliance	Manager of standards development and research programs	Quality assurance, auditable standards and sustainability across several agricultural commodities
Guay, Kimberly	Tarleton State University	Associate Professor	Use of CBD as horse supplement
Gurung, Nar	Tuskegee University	Professor	Use of hempseed cake with goats
Kasula, Raj	Wenger Group	Senior Vice President & Chief Nutrition Officer	Use of hempseed cake with laying hens
Kleinhenz, Michael	Kansas State University	Assistant Professor	Use of industrial hemp as feed for livestock
Komarnytsky, Slavko	North Carolina State University	Associate Professor	Measurement of cannabinoids in human tissues
Moran, Courtney	National Hemp Association	Chief Legislative Strategist	Hemp legislation
Newkirk, Rex	University of Saskatchewan	Professor	Research of hemp as feed ingredient in Canada
Smith, David	USDA ARS - Agricultural Research Service	Research Physiologist (Animals)	Measurement of cannabinoids in animal tissues
Swanson, Kendall	North Dakota State University	Associate Professor	Use of hempseed cake with beef cattle
Therrell, Austin	Association of American Feed Control Officials	President	Approval of feed ingredients
Tweet, Morgan	Hemp Feed Coalition	Executive Director	Hemp cultivation and processing

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The Workshop Program was:

Day 1

Time	*Title*	*Speaker(s)*
8:00-9:00	Check in	
9:00-9:30	Event welcome	Jeff Steiner
9:30-10:15	HFC Introduction	Morgan Tweet
10:15-10:25	Bathroom Break	
10:30-11:15	NHA Briefing	Courtney Moran
11:15-12:00	CHTA Briefing	Terry Grajczyk
12:00-1:00	Lunch	
1:00-2:00	Spent Biomass Review	Massimo Bionaz
2:05-4:00	Hemp Seed Meal	Kendall Swanson; Shawn Archibeque; Raj Kasula; Nar Gurung
4:00-5:00	Hemp Seed Ingredients	Rex Newkirk
5:00-6:00	Cannabinoids for Canines	Bill Bookout
6:00-7:00	Happy Hour	
7:00-8:30	Dinner	

Day 2:

Time	*Title*	*Speaker(s)*
8:30-8:45	2nd Day Welcome	Morgan Tweet
8:45-10:00	Flower/CBD Review	Michael Kleinhenz; Kimberly Guay
10:50-12:00	Cannabinoid Quantification	David Smith
12:00-1:00	Lunch	
1:00-2:00	Analytical Standards Panel	Mark Berhow; Michael Kleinhenz; Slavko Komarnytsky; Hunter Buffington
2:00-2:15.	Bathroom Break	
2:15-3:30	Regulator Panel Discussions	Charlotte Conway; Austin Therrell; Emily Febles
3:30-4:00	Bathroom Break	
4:00-5:00	Breakout sessions	
5:00-5:30	Regroup and review breakout	
5:30-6:00	Summary, next steps, closing remarks	Morgan Tweet
6:00–8:30	Dinner	

Each speaker provided a presentation with slides, as also did the panelists. During each panel discussion, panelists made 5-10-minute presentations before a round of questions.

The **breakout session** included the formation of 3 tables with participant selected by the organizers in each table, plus the online participant as a single group and, guided by the facilitators (Agung Irawan, Dr. Jenifer Cruickshank, and Dr. Jeffrey Steiner), each table had to brainstorm around the following questions:

1) If funding is one of the main issues, can we brainstorm some pathways of state, federal, and private funding that align with the goals of future research projects?

2) If we look at the Matrix CHTA has put together for research priorities, what could we do here in the United States to complement their research and potentially fast-track applications in both countries?

3) After hearing the presentations today and yesterday, what are some interesting findings that we think should be investigated further?

4) How can we engage other more established industries (i.e., Beef Cattle Association or Grain Growers Associations) to articulate hemp's potential value as a feed ingredient and entice them to help in the approval process instead of waiting for it to happen? Could the gov't have a role in helping make that happen?

5) How does the animal feed industry move ahead of FDA approval of human products and defined human TDI? What research would need to be conducted to generate confidence in regulators without having those limits defined?

6) If we believe hemp is one of the best carbon-sequestering plants in the world and could bring great value to US agriculture if incorporated into rotations, what products would be generated at volume, and what industries do we think would be first to adopt them into their feed programs?

7) Besides the above points and as the fruit of the talks at the workshop, what do you think is the major need/gap, and what research is needed to close that gap?

The virtual participants sent their responses via e-mail.

Summary of Presentations and Discussions

Industry

[Morgan Tweet]: An introduction and overview of the Hemp Feed Coalition (HFC) was delivered, describing in more detail the current status of the hemp industry, the hurdles that still remain, and the interactions the coalition has had with AAFCO and FDA-CVM. HFC elaborated on the challenges the hemp ingredients have faced, including the nascence of the industry, the competition with well-established and approved commodity crops, the back-and-forth dilemma described as the chicken or egg scenario, the limited number of processors and producers, and most importantly and probably most challenging, the conflation between cannabinoid products and traditional feed ingredients like protein, fiber, and oil.

HFC is a non-profit with a hyper-focus on one sector of the hemp industry, which sets it apart from other industry groups in that in existence. HFC is intentional to educate, advocate, and ultimately gain state and federal approvals for hemp ingredients in the animal feed sector. Mrs. Tweet's presentation also detailed the current AAFCO Feed Ingredient Definition application, "Hemp Seed Meal for Laying Hens", which HFC submitted in January 2021. At this workshop, HFC allowed both AAFCO President and lead FDA-CVM representative to present and to hear their transparent feedback. In summary, here are their thoughts:

1) There has been concern over FDA-CVM's requests for more sensitive and costly testing around an ingredient that is commonly known to be low in cannabinoid concentrations, especially when the studies and research presented in the application showed no safety concerns present.
2) There are concerns from the subsequent responses and conversations around the Laying Hen application that resemble the scrutiny reserved for medicated feed ingredients, not protein sources.
3) There is a lack of continuity in the responses from the multiple FDA-CVM staffers evaluating the application, forcing HFC to conclude that the process is not streamlined or efficient, especially for the amount of time allotted per each subsequent response and review.
4) The extremely detailed critiques of the safety study and laboratory practices are concerning and not warranted due to additional supportive information that was also included in the application along with standard acceptance of ASTM-approved procedures and ISO-certified laboratories.
5) Frustrations around the timelines and urges for an improved process (currently required to have a response in 180 days):
    a. 1st response = 164 days after submission
    b. 2nd response = 178 days after submission
    c. 3rd response = 181 days after submission
6) Overall minimal support from AAFCO, which concerns HFC and other organizations about their role in the process in general.

The presentation's conclusion included a short dialogue around HFC's opinion and role within state and federal policy. This organization was founded with no intentions of directly influencing or supporting policy or legislative matters, but members of the organization have sought their expertise and knowledge in reference to animal feed initiatives. The HFC's Board believes that if policy and initiatives are to be brought forth, it is better to be aware and hopefully educate and influence policy language that will best protect animals, processors, and producers. Mrs. Tweet ended her presentation by describing the value of the hemp industry and the need for open markets in the animal feed sector to support true growth.

[Courtney Moran]: As a representative from the National Hemp Association (NHA), Moran used her presentation to elaborate on the theme Tweet ended with describing the US National Hemp Industry in greater detail and the role her organization, NHA, has to play within it. A few noteworthy accomplishments NHA has been a part of include:

1) Generation of two reports to be delivered to the Biden-Harris Administration
2) Testimonies given at the 2019 US Senate Ag Committee Hearing
3) Collaboration between USDA AMS, USDA Foreign Agricultural Services, Customs, and SBA, and
4) Ongoing work with NGA, NASDA, State Officials, and State agencies.

NHA is a group known for its work with state and federal policymakers and used this time at the workshop to elaborate on the support they want to provide to help open animal feed markets through that pathway. The opportunities they outlined include:

1) Federal legislation to allow hemp grain ingredients for companion animals
2) Federal legislation to improve the animal feed ingredient application process
3) State-by-state efforts to approve hemp grain ingredients
4) Raise funds for additional animal feed studies

Moran finished her presentation, opening it up for discussion and dialogue between AAFCO and FDA-CVM. There was much discussion around the process and the resources available to the agency, which piqued interest from NHA and has since pursued additional funds to allow FDA-CVM to address applications more quickly. Charlotte Conway, lead representative from the agency, echoed her frustrations with the time it took to review applications and the agency's need for more dedicated staff.

[Terry Grajczyk]: As a representative from the Canadian Hemp Trade Alliance (CHA) and director of the Animal Feed Sub-Committee within CHTA, Terry delivered a comprehensive presentation of the hemp industry from a more global perspective and highlighted the work they are doing specifically around animal feed. CHTA reviewed global statistics around dedicated hemp acres and the market value and goals for the future years. They believe the five pillars to addressing the $1B hemp industry are:

1) Farming – genetics, agronomy, regulator
2) Food – domestic and international opportunities for grain-derived food ingredients
3) Feed – giant market but the clear need for regulatory approvals

4) Fiber – several interested markets and seemingly an abundance of opportunities
5) Fractions – also known as the floral or cannabinoid markets which are smaller in volume and restricted due to regulations and inconsistencies

CHTA is an active participant in developing and implementing standards across the five pillars and elaborated on the work currently being done with groups like ASTM. For example, Terry highlighted the need for continuity and clarity in the terminology around the different hemp ingredients.

Following the review of CHTA and its work, Terry went into greater detail about the Canadian Hemp regulations and how they may differ from the US. Some notable things highlighted include:

1) Farmers are also required to receive a license to grow and follow similar reporting requirements to the USDA
2) Canada has limited the approved cultivars for producers, managing the risk of higher-risk varieties at the certified seed level
3) Processors must also obtain a license to process hemp
4) Food products must contain <10ug/g total Delta-9 THC, there are currently no limits on other cannabinoids like CBD, CBN, etc.

Following more review of the regulatory environment for hemp in Canada, Terry extrapolated into the market data around hemp and its economic contribution. The remainder of the presentation was dedicated to the review of research ranging from cultivation research to, more specifically, work done around animal feed. Canada currently prohibits hemp from being fed to livestock and requires support and approval from CFIA. The ingredients CHTA focuses on for applications in animal feed include whole seed, hempseed fines, dehulled hempseed, hempseed hulls, hempseed meal, hemp protein, and hemp seed oil. The target species include ruminants for meat, ruminants for dairy, sines, poultry, and fish. Lead researchers Dr, Rex Newkirk (who was also in attendance) and Dr. Jim House were highlighted for their work with the Canadian Feed Resource Center for the trials and data collection. Compared to other well-established feed ingredients, comprehensive nutrient analysis has been completed and reviewed. Near the presentation's conclusion, CHTA reviewed a matrix that was generated to outline opportunities and priorities for feed research. This led to discussions around the need for collaboration between US and Canadian hemp industries and hopefully CFIA and FDA-CVM.

The intention of programming the workshop to kick off with discussions from industry partners was received well and set the stage for a productive and fruitful conversation. Allowing the industry to highlight the work that has been done, summarize the opportunity for hemp as an economic driver and, more specifically, as a viable feed ingredient, and then air their concerns with current practices and policies allowed for researchers and regulators alike to hear for themselves the importance of a workshop like this and subsequent work to hopefully follow.

Research and analytical

Spent hemp biomass (or pulp)

[Massimo Bionaz]: An overview of the various types of hemp (fiber, seed/grain, and cannabinoids), where the cannabinoids are produced in the hemp plant and the effect of pollination and subsequent seed set, and the importance of the production of spent hemp biomass (**SHB**) as a byproduct of the extraction of cannabinoids from hemp in the US. The nutritive characteristics of SHB were compared to alfalfa, revealing a high similarity, thus, concluding that, based on the chemical analysis the SHB is a good feed ingredient for ruminants. Dr. Bionaz evaluated the ingredient derived through two different extraction methods, and further information will need to be derived from the different manufacturing practices if this ingredient is to be considered further as feed ingredients.

The effect of feeding SHB on the health and performance of animals and the transfer of cannabinoids in animal products was presented for three experiments involving finishing lambs, lactating dairy cows, and broilers. Overall, the data indicated no detrimental effect on health by feeding SHB, especially in ruminants, with a consistent effect on inhibiting bilirubin clearance in the liver, which could be associated with decreased liver clearance, including drugs. This was true, especially in the studies with ruminants. Both studies revealed that the cannabinoids accumulated in the liver, muscle, and adipose tissue in lambs and in milk in cows while the animals were feeding SHB. The concentration of Δ9-THC in those tissues was barely above or below the Tolerable Dose Intake (**TDI**) as indicated by the European Food Safety Authority and the Food Standards Australia and New Zealand of 0.4 or 6.0 µg/kg BW, respectively. Although trace amounts of these compounds were found in these samples, all detectable levels mostly disappeared after 4 weeks of feed withdrawal in all tissue samples.

However, since a TDI for THC and CBD has not yet been determined in the US, it is an important standard that needs to be addressed. Finally, in a study performed in broilers where SHB was fed at 0, 5, 10, and 20% doses in the diet, initial observations indicated a lack of effect on feed intake but a decrease in growth in animals fed 10 and 20% SHB. In the same study, an increase in g/kg of BW of the liver and brain was observed with a larger stickiness of the feces. The reason for those findings is still under investigation.

Overall, SHB showed real promise for a feed ingredient due to its high feed value and current low cost of goods. Of all the potential hemp feed ingredients evaluated in the workshop, this was a higher-risk ingredient in cannabinoid concentrations. Due to variations in extraction methods and effectiveness, this ingredient is likely to possess a higher range of naturally occurring cannabinoids and, as shown in these studies, does seem to accumulate in some samples.

No performance or health concerns were observed across the studies performed in ruminants, except an apparent low palatability of SHB in the short period that affected feed intake (but the effect disappeared after 1 month of feeding SHB, at the least as observed in lambs). A potential concern is decreased liver clearance, which needs further evaluation. The SHB does not appear to be a good feed ingredient in broilers, as it negatively affects performance if fed >5% in the diet. In ruminants, cannabinoids are detected during the feeding of SHB but disappear quickly in the various tissues, inducing fat, after the feeding trials eventually dissipated and were undetectable at a maximum of 4 weeks of withdrawal.

Hemp seed meal

[Kendall Swanson] Hemp seed meal (HSM) is produced by extracting oil from the hemp seed. Nutritional analysis of HSM reveals a high value of protein and fat similar to corn Distiller's Dried Grains (DDGS) but with higher fiber, especially undigestible fiber (i.e., ADF). HSM currently has an ingredient application in AAFCO and is defined as a protein source. In two subsequent experiments at North Dakota State University, HSM was fed to finishing beef heifers at 20% of the diet. Feeding HSM negatively affected daily weight gain, final body weight, and hot carcass weight, ultimately decreasing the growth efficiency when directly compared to DDGS. The reason for this effect was likely due to a lower digestibility and higher duodenal flow of ADF. Despite the lower overall digestibility, the ruminal digestibility of protein in HSM is higher than in DDGS and results in a more favorable N balance. Tissue, plasma, and blood samples from this study were analyzed by the USDA ARS laboratory in Fargo for cannabinoid quantification and were reviewed later in the workshop.

[Shawn Archibeque] Hemp seed cake (HSC) with no detectable cannabinoids was fed at 5 levels (0, 5, 10, 15, and 20%) in isonitrogenous and isocaloric diets of finishing castrated male sheep at Colorado State University for 90 days before return to a balance trial for 7 days and harvested. No difference in performance, morbidity, blood chemistry, mortality, and carcass characteristics was detected, although a numerically better performance was observed for 15% HSC inclusion. It was concluded that the HSM is a valuable feed ingredient for lambs if included in less than 20% of the diet. Dr. Archibeque noted that the initial trends for decreased consumption and body weight at or above 20% were expected and similar to other oilseed meals that are traditionally used in feed like flax, or soybean meal.

[Raj Kasula] A study with laying hens fed at 4 levels of HSC (0, 10, 20, and 30%) for 16 weeks revealed a positive effect on body weight, external egg quality (egg mass and eggshell strength), and internal egg quality (yolk pigmentation, lutein content, and % fatty acids and level of PUFA, particularly omega 3). A negative effect was observed for livability and egg production, but this was attributed to external factors in the study, including excessive handling, barn temperature, and other unknowns. No differences were observed for food conversion rate, blood parameters, gross and histopathology of liver, spleen, kidney, and duodenum, gut health, or bone strength, and there were inconsistent effects on manure characteristics. Cannabinoids were analyzed using HPLC at a LOQ of 25 ppm and were not detected in the HSC, blood, breast meat, body fat, kidney, liver, spleen, or eggs. When lower levels of detection (1 ppm) were requested for the ingredient and the food byproduct (eggs), trace amounts were found in the cake, but still undetectable levels in the egg. Compared to other feeds typically used for laying hens, HSC has similar protein content, tends to have more fat and minerals, and a lower ratio of omega 6/omega 3 fatty acids that are favorable.

In a subsequent field study with no replicates (the control was the rest of the farm), hens were fed 20% HSC and monitored to confirm the original conclusions on the safety and efficacy of the ingredient. The results showed no effect on livability or egg production, but decreased feed intake and improved feed efficiency, body weight, and egg size. It was concluded that HSC is safe and effective to be used as a feed ingredient for the production of eggs by laying birds.

[Nar Gurung] In a study with finishing intact male goats carried out at Tuskegee University, HSM was fed at 0, 10, 20, and 30% in isocaloric and isonitrogenous diets for 60 days. The HSM was very similar to the one described by Dr. Swanson, with high protein and ADF with no detectable

cannabinoids. Gain of body weight as well as dressing percentage were negatively affected when HSM was included in diets but other carcass characteristics were not affected. It was concluded that performance was still acceptable and HSM could be a valuable and safe feed ingredient for goats. Dr. Gurung speculated that the higher fiber content in the ingredient was responsible for the decreased growth when HSM was included in the goat diets.

Hemp seed products as a feed ingredient in Canada

[Rex Newkirk]. The Canadian Feed Research Center (CFRC) has a feed research mill where they perform commercial contract feed testing. The mill has 3 processing lines consisting of lab scale, pilot scale, and industrial scale. The registration process for any feed ingredient in Canada, including hemp, requires a minimum of 3 studies showing safety and efficacy for every animal and production stage class. The Canadian Food Inspection Agency takes about 2 years to review applications. The Canadian hemp market consists of hempseed, hemp hulls, dehulled seeds, hemp seed oil, hemp seed meal, hemp protein concentrate, and hemp screenings. A significant portion of the cannabinoids in hemp food products are in the acidulated form, hence it can be converted to the standard form through heat treatment. The nutritive characteristics of the hemp seed change substantially if the seed is dehulled, with increased fat content and decreased ADF when dehulled vs. whole seed. The CFIA is mainly concerned about consumers unknowingly consuming cannabinoids.

A summary of the data in literature being used in a food application for hemp seed meal (HSM) in Canada included studies on several species. There were 5 studies on birds, 3 in broiler chickens where hemp seed was included at different levels (from 0.2% to 18%), one in laying hens, and one in Japanese quail. In these studies, it was observed that there was either no effect or positive effects on the fatty acid composition of the meat or eggs, better gut health, lower cooking loss of the meat, and better bone health. When measured, cannabinoids were not detected in meat. Two studies were conducted in pigs, one study in growing pigs and another in lactating sows and piglets. In the growing pig study, a blended product of hemp hull and pea did not affect the net energy of the diets. In the sows, 5% inclusion of HSM in the diet increased milk yield and improved the fatty acid composition of the milk. In steers, HSM inclusion improved the proportion of PUFA in meat. In two separate studies in dairy goats and sheep, including HSM in the diet at 9.4% of the diet or 175 g/d improved milk fat yield and quality (i.e., PUFA). There are planned studies in Canada to assess the inclusion in the diet of hemp seed hulls and screenings. The priority studies required for including hemp seed as a feed ingredient are one study in dairy cows, 3 in growing pigs, 3 in lactating sows (dehulled), and 3 in salmon (dehulled).

Dr. Newkirk also shared a matrix of ingredients by species that CHTA put together , organizing existing and available publications and prioritizing future studies. This matrix is proprietary to CHTA and potentially available upon request.

Cannabinoids for canines

[Bill Bookout]. Research conducted by National Animal Supplement Council (NASC) looks at products for nonhuman food chain animals such as dogs, cats, and horses in the United States. They handle only food or feed supplements and dosages of animal health products or products for a non-nutritional health benefit. Normally, these products contain ingredients that are not approved for

inclusion in nutritional products. The NASC follows published standards from the FDA under 21 CFR part 111, and standards from the Food Safety Modernization Act under CFR part 507.

The NASC Adverse Event Reporting System (NAERS) requires data entry and information from member companies. This is information on the product label; the amount of ingredients claimed, whether it is a nutritional product with guaranteed analysis or is a product for non-nutritional health benefits with guarantees as active ingredients. 100% of the ingredients are required to be declared. NAERS tracks over 6,500 products and over 1,400 individual ingredients. Member companies also enter the number of units in each package to the first point of distribution, and the FDA is provided access to this information. A type of complaint where an animal has suffered negative physical effects or health problems that may or may not relate to the use of the product is known as an adverse event, such as vomiting and diarrhea, or a serious adverse event, i.e., renders the animal unable to function normally requiring professional diagnosis and determination. The NASC ran an ingredient risk report for hemp and all hemp-derived products. The last report stated that there are 11,135 products in the marketplace. The data can be reduced to various cannabinoids (e.g., CBD) of hemp. The report includes a statistical analysis of mg/kg body weight for dogs, cats, and horses. In dogs, there were 719 million administrations, 1,624 adverse events, and 8 serious adverse events; in cats, there were 123 million administrations, 54 adverse events, and 2 serious adverse events; in horses, there were 6 million administrations, 26 adverse events, and 1 serious adverse event; in total, there were almost 850 million administrations, 1,704 adverse events, and 11 serious adverse events. Although not official safety data, results indicate that hemp products do not pose a high risk to the species tracked.

NASC has a random product testing program by purchasing products from the marketplace and testing for label claims. In the case of hemp, 62 products were tested, and none of them had THC levels higher than 0.3%, most of them were close to 0. They also test CBD for companies claiming CBD on the product label.

The NASC conducted a 90-day safety study on dogs followed by a 14-day washout period. The administration rate used was 5 mg/kg body weight for CBD, 50-50 split CBD/CBDA, and 50-50 split CBD/CBDG. The objective was to determine the maximum safety levels of CBD in dogs. Initial data indicated that there was a slight increase in cannabinoids in the blood of some dogs but returned to normal values during the washout.

Hemp flower

[Michael Kleinhenz] Cattle can easily use byproducts. There is a good selection of byproducts to be used as feed ingredients for cattle, but the price volatility makes using byproducts from hemp very attractive. A Kansas State University (KSU) study of the nutrient composition of various hemp plant parts indicated a higher quality when using flowers, leaves, or seeds than other parts. This was especially the case for crude proteins. The cannabinoid levels were also measured, with the highest levels detected in flowers and leaves, with minimum levels measured in whole plants, seeds, and stalks. Overall, there is a paucity of nutritive data for hemp. In another study conducted at KSU, heifers fed feeding hemp flower to target a dose of 5 mg CBDA/kg BW had a rapid increase level of cannabinoids, particularly CBDA, THCA, CBDVA, and CBCA, with an increase proportional to the level of each cannabinoid in hemp flower, except for CBDVA that was lower than proportional. In a third study at KSU, Holstein's calves fed the same dose of CBD as hemp flower allowed to determine Tmax (7.5 h), Cmax µg/mL, and half-life ($T_{1/2}$; 23h) for CBD. In a fourth

study, Holstein steers were fed with 25g of hemp flower/day to reach 5 mg/d of CBDA. Besides determining the pharmacokinetics of cannabinoids that were similar to the prior studies, feeding hemp flower decreased cortisol and inflammatory prostaglandin E in the blood and increased the laying time feeding. A pilot study tested the effect of feeding industrial hemp to repeat transport in Holstein steers. The hemp-fed cattle did not lose as much weight during the transport and had lower cortisol coming off the trailer than the control animals. However , when not transported, hemp-fed had a higher cortisol level than the control steers.

It was concluded from these studies that cannabinoids are readily absorbed from the rumen and GI tract but have low potential to accumulate in the body, and each cannabinoid has its own pharmacokinetic properties. Feeding high-cannabinoid hemp reduces stress and inflammatory biomarkers in cattle and appears to be safe, although based on limited data.

Studies on Hemp and CBD in Horses, Rabbits, and Cattle

[Kimberly Guay]. A series of experiments were conducted at Tarleton State University where several species were fed with CBD oil, nano-treated CBD (NTCBD), and hempseed meal.

Horses were fed with 0.3 or 0.6 mg CBD/kg BW for 5 days. Data revealed increased feed and water intake and CBD levels in the blood, decreased vocalization, and no difference between sexes. Horses were fed with HSM pellets for 6 days, and it was determined that the palatability of HSM was more palatable in the horses than soya bean meal and sugar beet pulp but had similar palatability to rice bran. Young stallions were fed 500g each of a control diet, soybean meal, rice bran pellets, beet pulp pellets, and hempseed meal (HSM) for 90 days. HSM affected the blood chemistry and decreased testicle and epididymis weights but did not affect semen motility and concentration, with some small effect on libido and sexual behavior. An in vitro digestibility trial using feces of horses fed with soybean meal, rice bran meal, and hempseed meal (HSM) for 30 days revealed that HSM had an NDF close to that of alfalfa but had the lowest IVNDFD and IVADFD.

Pregnant rabbits were fed CBD tincture (0.6 mg/kg BW), NTCBD (0.6 mg/kg BW), or Olive oil at equal volumes. Results revealed no effects on Dam feed intake or liver and spleen weight post-weaning.

Cannabinoid Quantification

[David Smith] The USDA ARS developed methods to measure cannabinoids in animal products and collaborated on several studies.

Residue depletion of cannabinoids in tissues was assessed in cattle from the study of Kendall Swanson (see above) by using newly developed rapid quantification methods for cannabinoid residuals in several animal tissues. The newly developed rapid method, which does not use the time-consuming extraction and cleaning method and the LC but directly uses the MS after a rough extraction (RS-ESI-MS), had a high correlation with LC-MS/MS, working well in kidney, liver, and muscles after matrix optimization. The rapid method includes the extraction using an internal standard, 10% Na_2CO_3, and ethyl acetate plus hexane extraction step. The MS-MS run was one minute. The newly developed methods had sensitivity and replicability as for the LC-MS/MS but could not separate between CBD and THC with some small differences as recovery and sensitivity between the various measured tissues, including liver, muscle, adipose tissue, blood and urine from the North Dakota University beef study.

Using the samples from Heifers from the pharmacokinetic study of Michael Kleinhenz (see above), it was confirmed a very high similarity between the analysis performed at USDA ARS and Kansas State University.

Using the samples collected at 0, 1, 4, and 8 days after withdrawal of HSM in beef cattle (see the study performed at North Dakota State University above) and measured in muscle, liver, kidney, and fat. It was determined that there were no false positives in the urine. CBDA and THCA were consistently measured in the urine, no false positives were detected in the plasma, CBDA rapidly disappears in the urine and liver after HSM withdrawal (a couple of days), no cannabinoids were detected in muscle but were abundant in the kidney, and the only neutral cannabinoids measured were CBD/THC in all the animals.

Ongoing studies

At Tarleton State University, Kimberly Guay is feeding bulls 20% HSM and cottonseed meal for 21-day periods. Preliminary data revealed no difference in body weights, but more data/tissue are being collected, including blood chemistry, serum cannabidiol, serum testosterone, muscles, and liver biopsies.

At the University of Tennessee, Kristine Ely fed horses hemp seed oil to assess the effect on inflammation.

At North Caroline State University, David Suchoff is the director of the Foundation for Food and Hemp Research Consortium, which consists of 3 academic members and 10 industry partners to foster collaborative cross-cutting research that addresses many challenges the hemp industry faces.

At Oregon State University, Jennifer Duringer started a metabolomic analysis of samples collected from the study where lambs were fed spent hemp biomass (see research presented by Masimo Bionaz above). Jenifer Duringer and Juliana Ranches surveyed hemp processors to identify the amount of spent biomass being produced, their extraction methods, type of varieties being used, among others. They are also looking to conduct a consumer survey in Oregon, to get an idea of the consumer's attitudes on the concept of using spent hemp biomass as feed for food-raising animals. They have also surveyed livestock producers to get their thoughts on the idea of using spent hemp biomass as a feedstock.

Analytical Standards Panel

Cannabinoid Quantification in Animal Tissues [Michael Kleinhenz] Analysis should be developed using the FDA guidance for industry #207. The animal tissues that are of interest are the liver, kidney, muscle, fat, plasma, and milk. The tissues are homogenized and then centrifuged. The supernatant is collected and then cleaned using solid-phase extraction. The extracted fluid is dried down at 40°C, then reconstituted with methanol for analysis. LC-MS/MS method is used to measure peaks of detectable cannabinoids in these samples.

Characterization of the Chemical Composition of Hemp Cultivars [Mark Berhow] Out of 150 different possible forms of cannabinoids, only about 10-15 are prominent in dried flowers. Among different types of extraction protocols, ethanol extraction provides the highest recovery and consistency with a single-step overnight extraction. There are concerns about inter-lab variabilities. The same sample was sent out to over 100 labs in a NIST study to determine the

variability. Results show that the low THC samples have relatively higher variations while those with high THC have relatively lower variations. Also, samples with higher CBD concentrations have lower variations in CBD, while samples with lower CBD concentrations have higher variations. Using 6 samples and identical methods between labs (except the HPLC system setup) also highlighted differences between laboratory results. Other things currently being worked on include hemp essential oils: terpenes, which is complicated because essential oils are volatile.

Cannabinoid Quantification in Hemp Products and Biological Fluids [Slavko Komarnytsky]

HPLC is sufficient when detecting cannabinoids in hemp plants, botanical oils, or some human biological fluids, e.g., urine, HPLC can be used. To detect CBD in plasma and tissues, LCMS can be used. Besides the cannabinoids, metabolites such as 7-OH-CBD and 7-COOH-CBD should also be measured. CBD metabolism in animals is different in every animal species. In a case study, 30 ml CBD from full spectrum hemp (1.2mg THC) was fed to healthy people twice a day for 10 days, CBD concentrations in the urine reached a maximum level after 4 days of treatment with 7-OH-CBD making up about half of the CBD present in the urine. No amounts of Δ9- THC were detected in urine with the detection of 11-OH-THC that reached a maximum at days 4 and 5 of treatment.

Lab Method Update and Opportunities for Collaborations [Hunter Buffington] There are limitations in cannabinoid identification and quantification between laboratories, but also opportunities to improve methods and consistency between labs. The ASTM D37 Cannabis Committee is hosting a subcommittee that has been working on hempseed products for use as animal feed and plans to extend this into hemp-fed animal byproducts for human consumption. The task group was formed to create standards for the quality of hempseed products for animal consumption and includes regulators and the role of a liaison with the AAFCO laboratory methods and standards development committee. To be able to propose standardized methods, there must be laboratory studies and a comparison of data. It is also important to bridge the gap between research labs and regulatory labs. Some Department of Agriculture labs will not accept hempseed materials because they do not have the ability to prove that it is unadulterated, which requires analytical methods that can quantify THC at the low concentrations allowed in hempseed products for human consumption. The ASTM task group is working to connect chemists, regulators, and researchers working on developing methods to address this. The goal is to identify experts to develop methods, and then distribute them for validation in research, private and regulatory labs. The task group is also planning workshops on understanding current research needs, detectors, limits of quantification, and gaps in methods for feed ingredients and hempseed by-products.

The reason for creating the task groups was the long relationship that ASTM has had with hemp grain and fiber worldwide, which included 700 members coming together to develop hempseed by-product standards. The specifications for food safety and quality of hempseed products for human consumption include microbial and moisture content, product integrity, and shelf-life considerations. The FDA allows 10 ppm in its acceptance of a Generally Recognized as Safe (GRAS) notice for hempseed hearts, oil, and protein powder for human consumption, but 20 ppm was set as the action limit in the ASTM standard because it was suspected to be more appropriate. However, the data reinforces that 10 ppm is sufficient for a threshold. Hence more data would be useful to make a final decision. For those interested in developing lab methods, it is recommended that ASTM be a great place to have their voices heard. Collaborating with regulators and food processors is important to get the sampling and methods right. The ASTM task group on animal feed is working with AAFCO to ensure the safety of hemp products. We have been talking to

regulatory labs about their capabilities and the detectors they use, including chemists from other countries, including Canada, to develop methods for alternative detectors and matrices for low and trace cannabinoid concentrations in hempseed by-products.

The Lab Methods and Services Committee is responsible for:

- Developing and standardizing lab methods for feed laboratories. This will be done by preparing a survey to understand the methods and detectors used in the field labs. The survey will also help to understand how many people are using the GC-FID method and what methods the regulators depend on.
- Creating a subcommittee to assist labs in preparing hemp as feed ingredients.
- Supporting a liaison with the ASTM subcommittee working on developing methods for animal feed.
- Providing expertise on the current capabilities of GC-FID to reach 200ppm LOQ for current approved methods.
- Working with the ASTM committee to develop methods for multiple matrices that can be used to quantify THC and CBD concentrations in trace amounts.
- It includes Canadian Food Inspection Agency members and other feed regulators.

Q&A Analytical Panel

[chaired by Massimo Bionaz]

Mark, can you please go into more detail about the variations you have seen in cannabinoid quantification in the plant? Are there any parts of the plant (i.e., seed, stalk, or flower material) that provide more consistent results and/or are relatively low in cannabinoids?

A: Hemp seeds do not have cannabinoids. The cannabinoids that are found there are only from contamination from the flower material. So, cannabinoid concentrations in seeds will vary depending on the cleaning process.

Mike, what has been the most challenging part for your analytical team in evaluating the cannabinoids in the animal tissue samples? Would the rapid quantification method David mentioned earlier be helpful?

A: The biggest challenge has been making a matrix for analysis, making sure each sample meets the internal standards. So rapid detection, as developed by David, will benefit the industry.

Slavko, since you have worked with many finished human products and human samples, what order of magnitude of levels of cannabinoids are you most likely to see, and how do they compare to the data and information you have seen here this week?

A: People are willing to consume products with high cannabinoid levels. But in animal feed, there is the risk of people consuming animal products unaware of the fact that he is consuming cannabinoids from the animal tissues. Talking about safety and toxicity from the regulatory perspective, there are minimal to non-existent risks. On the topic of selenium in bread, 99% of consumers are probably unaware that they are ingesting selenium. And it can be expected that the same thing will happen with cannabinoids, with probably 99% of consumers unaware that they are ingesting cannabinoids in the smallest ppb quantities.

Hunter, how is the general knowledge of cannabinoids within AAFCO and ASTM? Do you still think there is a level of fear of the unknown? How can research address those fears if they are still present?

A: There is a good understanding of the ingredient identity and its THC and CBD profiles. There are questions about whether it acts as a pharmacological substance and what bioavailability means for tissue residue. This research can help extrapolate how it appears in byproducts and the safety concerns when hemp-fed animal by-products enter the human food chain.

Mark, I know another issue is the standardization of cannabinoid detection between commercial laboratories. What could be a good strategy to address that issue?

A: A good strategy is forming a team of laboratories to pull their message into results and look at samples. NIST has carried out several candidate standards, sending the same sample to several analytic labs to get results. Private labs will never be transparent about their analytical methods, but referencing a peer-reviewed published analytical method can help in standardization.

Hunter, what value do ASTM subcommittees bring to regulators and their process of evaluating ingredients?

A: About 700 volunteer experts come together to provide guidance, and standards and to validate methods through consensus. The resources and expertise that the volunteer members of ASTM bring to fruition are incredible. ASTM was also suggested as a lead agency to develop analytical methods by the USDA in its Final Hemp Rules, showing a level of trust in the results.

FDA: On whether the FDA will accept consensus from the ASTM committee, it will be happy to look at the data presented and analyze it for safety.

Slavko, in your opinion, what is the level of risk for humans consuming animal by-products that were fed hemp ingredients, and what is the PERCEIVED level of risk?

A: The risk levels are currently unknown because there is little research on this. Also, there are a lot of ethics involved in human testing, so it is advisable to contact the FDA first before engaging in that.

Q&A Regulatory Panel

[moderated by Morgan Tweet]

The following questions were asked of the **regulatory panel**:

Austin, I think you will agree that the approval of Hemp is an issue that impacts every state, and a responsible path forward would be in everyone's best interest. AAFCO has an ingredient definition process, which an AAFCO investigator leads depending on the ingredient. What can AAFCO do to bring other states into the process by providing expertise, contributing research or information, or other resources that would help expedite the process, better support the AAFCO Investigator, and help answer CVM's questions?

Charlotte, one of the issues when talking with the FDA is the LoQ for cannabinoids. There is not an official LoQ for the hemp byproduct as of now. Do you have a plan at FDA to provide a LoQ or to determine a TDI for cannabinoids in animal products?

Emily, where do you see USDA's role in supporting this effort of understanding and incorporating hemp in the feed market? Can you explain in more detail where the handoff is between the USDA authority and FDA-CVM?

Charlotte, at the AAFCO meetings, the "process" was described as deliberative, which the industry views as meaning slow. How do you see the role and processes evolving in the agency as we live in a time of ever-increasing technological advancement, and how can FDA-CVM be more supportive of technologies (hemp production being one of them) that have a real shot at providing meaningful solutions to our climate crisis and sustainably conscious culture?

All Panelists: One issue with hemp is that Congress legalized the growing of Hemp as an Agricultural Commodity without considering the ramifications or products created when hemp is processed. What ideas do you have, and what are your suggestions to try and help deal with the proliferation of products that cross your regulatory boundaries?

Research priorities and needs identified

Industry

The industry recognizes the need for continued collaboration between regulators, researchers, and industry. Funding is limited in the industry, and it is challenging to coordinate efforts to maximize the little available public funding there might be. Industry representatives, including HFC and CHTA, have committed to continuing their work in parallel and supporting each other's efforts when possible. The Global Hemp Innovation Center has also committed to coordinating efforts for future grant opportunities. The Center realized its potential role in the conversations had over the two-day workshop and had an opportunity to continue facilitating research efforts in coordination with the needs of the industry.

Regulators

The regulators did not specifically identify any research needed but highlighted the need for a solid and data-driven argument to support the safety of products from animals fed with hemp byproducts using already produced data. However, they recognized that a TDI is missing and would be useful to have.

Research

The presentation by the researchers highlighted the need for further research to determine the proper inclusion amounts for each hemp byproduct. The determination of metabolites of various cannabinoids also was highlighted as a gap. The research on using hemp byproducts with monogastric species is lacking, especially for companion animals (specifically dogs and cats) and production animals, such as pigs. The use of hemp byproducts as silage and research on grazing hemp is also missing. The most important issue that was highlighted by the discussion was the determination of tolerable dose intake (TDI) and/or the safety of products from animals fed with hemp byproducts. According to FDA representatives, the use of animal models would be acceptable to support safety.

Outcomes

The present white paper defines the fundamental research needed to move forward with legalizing hemp and its byproducts as feed ingredients. This can be considered a primary outcome; however, during the breakout session, it became evident that a collaborative effort could better address the research needs identified. Thus, a major outcome was the agreement to work on collaborative research that would use the information gathered during the workshop, especially the identified research needs and priorities and the opportunity offered by the two-day, in-person meeting that allowed interaction between researchers and researchers with industry representatives and regulators.