Biochar Use In The Livestock Industry

Research and Market Insights for Livestock Producers and Biochar Producers

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Executive Summary

Biochar has been successfully used in livestock operations as a feed additive and as a manure management tool. Using biochar as a feed additive is widespread in Europe; its use has been limited in the US due to the FDA's feed additive regulations, but current research efforts and state level approvals have opened both pilot-level and production use.

The larger, more immediate opportunity for biochar-in-livestock-operations may come from the manure management aspect. No approvals are needed and there is a large body of research and experience supporting biochar's benefits in bedding, manure management, anaerobic digestion, and compost. Most biochar will end up in the soil, where its benefits are supported by extensive research as well as being well established in practice. Biochar has shown to reduce ammonia levels and retain nitrogen compounds in manures and it provides increased water holding capacity and soil organic matter in soils. An additional benefit to an investment in biochar is its longevity—measured in decades to millennia—which also opens the potential for economic benefit from the developing carbon credit markets.

For biochar producers, there are over 250 million tons of feed for livestock consumed annually, with about 1.4 billion tons of manure produced. If one percent of those input and output streams use biochar (at rates of 0.3% and 10% respectively,) 1.5 million tons of biochar would be needed.

The first two sections of this report provide the research and practical experiences in support of biochar's benefits. The third section is for herd and flock managers specifically, addressing the questions of how best to take advantage of biochar with your livestock. And the last section offers biochar producers guidance on how to serve the livestock market effectively.

Photo credit: High Plains Biochar

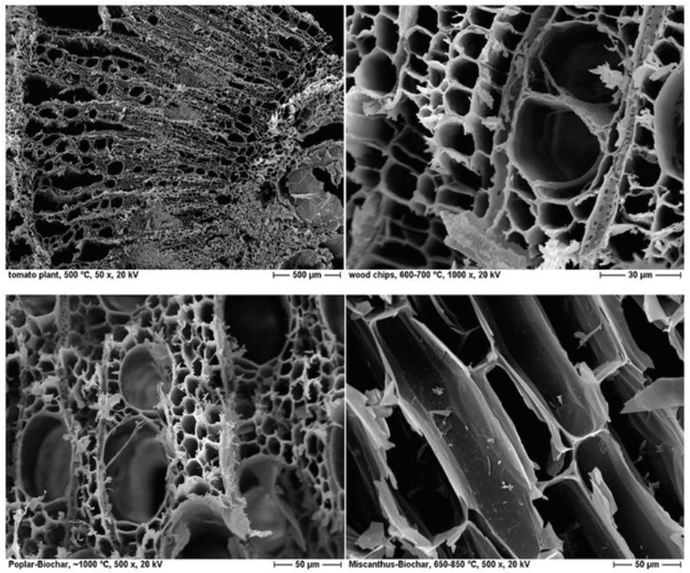
Introduction and Overview

This report looks at using biochar within the livestock industry as a feed additive or as a bedding/manure management tool. Both applications provide unique market opportunities, but limitations do exist, particularly in the feed sector. Biochar is common as an animal feed in Europe where a certification process is in place. That's not the case in the US where the Food and Drug Administration has the responsibility to regulate animal feed. A brief spotlight on the regulatory hurdle is included in Section 2, but to understand the full scope and rationale, a comprehensive look at the regulations and the process for gaining approval from the FDA is included in Appendix A and, for comparison, the European Biochar Certificate requirements provided in Appendix B.

A more immediate opportunity is using biochar in animal bedding and/or for manure management. This provides the producer with value added opportunities as well as an effective tool to reduce ammonia and methane emissions and to retain nutrients. While anaerobic digestion is an increasingly common manure management solution in the US, to which biochar can add value, it is outside the scope of this report. For simplicity, the word livestock is intended to include all food animal species unless called out specifically.

For those unfamiliar with biochar, it is the product of heating organic feedstocks[1] in a low oxygen environment, a process called pyrolysis. Processing temperatures for biochar range from 400 to 1000C and, depending on the specific feedstock, temperatures, and post processing, will produce a granular high-carbon product. Biochar's primary characteristic is its huge surface area in a long-lasting[2] matrix of almost pure carbon illustrated in Figure 1. A more detailed look at biochar's characteristics is included in Section 1.

Figure 1. Photomicrographs of Various Pyrolyzed Feedstocks



Glaser, B, Wiedner, K., Biochar-Fungi Interactions in Soils; February 2013; DOI: 10.1201/b14585-4

The first two sections provide both the research and practical experiences in support of biochar's benefits. The third section is for herd and flock managers specifically, addressing the questions of how best to take advantage of biochar with your livestock. And the last section offers biochar producers guidance on how to serve the livestock market effectively.

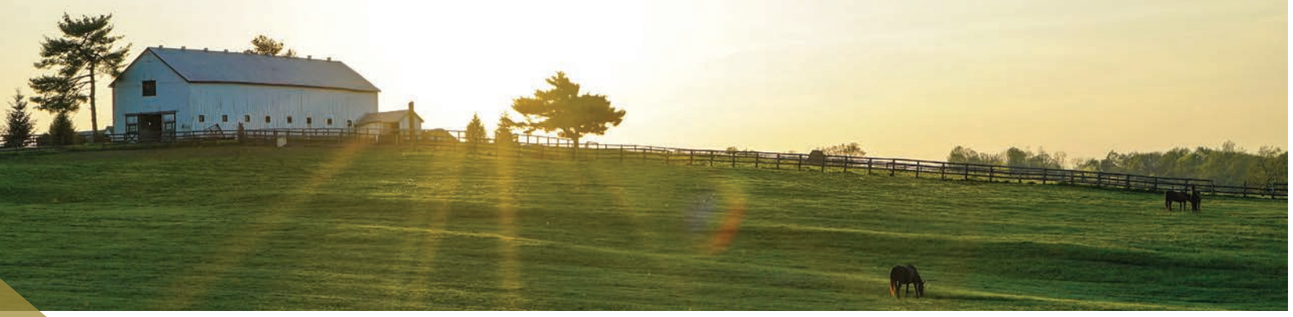
While biochar has shown the potential to benefit livestock through improved animal health, the long-term benefit is its end use in the soil, especially when that biochar is combined with manure or compost.

These benefits have the potential to be enhanced through the developing carbon credit market, which could significantly enhance the economics of biochar's use—discussed further in Section 3.

[1]Feedstocks range from woody to grassy, bones, manure, livestock litters, and other inputs to create specialized chars.
[2]Biochar is considered a stable carbon product for decades to millennia.

Section 1.

Research Supporting Biochar's use in the Livestock Industry



Section 1. Research Supporting Biochar's use in the Livestock Industry

Research has proven biochar useful in a variety of settings within the livestock industry (i.e., different animals, different uses and treatment regimens, and different soils). The most cited benefit in livestock as a feed additive is to increase feed efficiency and reduce methane emissions.[3] As a bedding enhancer, biochar is known for its capacity to reduce ammonia. Once applied to soil, biochar has the potential to increase water holding capacity and promote greater nutrient utilization, among other soil health indicators.

Before delving into the science of biochar's use within the livestock industry, it's important to note that in the US, the FDA regulates feed additives for livestock and only approves biochar as a feed additive on a case-by-case basis. There are suppliers of biochar for livestock feed approved at the state level only. Many states follow the FDA approval process, but some allow the use of biochar as an additive as long as the firm complies with the reporting requirements and pays the requisite taxes. Firms interested in using or selling biochar will need to check with their state-level feed regulation agencies to determine their best course of action. A detailed explanation of the FDA requirements are included in Appendix A, and the EU approval process is included in Appendix B for comparison. References for California's livestock feed approval process on page ??? are also included for comparison. One benefit of obtaining FDA approval is to allow for interstate commerce by satisfying the requirements of many states

The following **Articles** highlight research which support benefits of biochar:

- Increased feed efficiency: 1, 2, 3, 5
- Decreased Emissions: 1, 2, 5, 6, 7, 8, 9, 14
- As a Compost Enhancer: 3, 4, 5, 6, 8, 10, 11, 12
- Anaerobic Digestion: 6, 14
- Increased Soil Water retention: 4, 11, 12
- Increased Soil Carbon: 12, 13
- Nutrient release leveling: 5, 6, 7, 9, 12
- Soil structure management: 1, 3, 4, 6, 7, 8, 12
- Soil Biota improvement: 4, 6, 7, 11
- Soil contamination mitigation: 5, 7, 11

1. A recent publication summarizes the state of biochar-livestock knowledge up to the year 2019 by evaluating 112 relevant scientific publications[4] which address both the biochar input and manure outputs. It notes that, "since 2010, livestock farmers increasingly use biochar as a regular feed additive to improve animal health, increase nutrient intake efficiency and thus productivity. As biochar gets enriched with nitrogen-rich organic compounds during the digestion process, the excreted biochar-manure becomes a more valuable organic fertilizer causing lower nutrient losses and greenhouse gas emissions during storage and soil application."

[3] Biochar and Livestock | US Biochar Initiative (biochar-us.org) and Biochar for animal feed - ARTi

[4] **The use of biochar in animal feeding;** Schmidt H-P, Hagemann N, Draper K, Kammann C. 2019; PeerJ 7:e7373 DOI 10.7717/peerj.7373

The analysis showed: "in most studies and for all investigated farm animal species, positive effects on different parameters such as toxin adsorption, digestion, blood values, feed efficiency, meat quality and/or greenhouse gas emissions could be found when biochar was added to feed."

The study noted the importance of knowing what the biochar is with this: "most of the studies did not systematically investigate biochar properties (which may vastly differ) and dosage, which is a major drawback for generalizing results. Our review demonstrates that the use of biochar as a feed additive has the potential to improve animal health, feed efficiency and livestock housing climate, to reduce nutrient losses and greenhouse gas emissions, and to increase the soil organic matter content and thus soil fertility when eventually applied to soil. In combination with other good practices, co-feeding of biochar may thus have the potential to improve the sustainability of animal husbandry."

The authors also noted that none of the activated or nonactivated biochars used as a feed additive or veterinary treatment had toxic or negative effects on animals or the environment. No negative side effects were reported either in short-term or long-term administration trials.

2. The report about the University of Nebraska at Lincoln's research on biochar fed to cattle[5] showed modest metabolic effects, but significant effects in methane emissions:

Two metabolism studies were conducted to evaluate the effects of biochar (0, 0.8, or 3% of diet dry matter) on digestibility and methane production in growing and finishing diets. Intake was not affected by biochar inclusion in the growing diet but increased with 0.8% biochar inclusion in the finishing study. Digestibility tended to increase quadratically with biochar inclusion in the growing study while digestibility tended to linearly decrease with biochar inclusion in the finishing study. Methane production (g/d) decreased 10.7% in the growing study and 9.9% in the finishing study with 0.8% biochar compared to no biochar. Methane production was reduced 10.6% and 18.4% in the growing and finishing studies, respectively, when measured as g/lb of intake. Although biochar is not FDA approved for animal feeding, the initial research shows potential as a methane mitigation strategy in both growing and finishing diets.

3. A paper on the European experience with biochar as an animal feed[6] notes that 90% of the biochar produced in Europe is used in livestock farming. "Whether mixed with feed, added to litter, or used in the treatment of slurry, the positive effect of biochar very quickly becomes apparent."

4. A publication[7] on biochar in poultry bedding focuses on the absorptive qualities of the char and explains the mechanism of it's use in the bedding to reduce ammonia production. [The author's experience is that biochar should, depending on the type of litter, be mixed 5-10% by volume with the usual litter.] "Biochar has a very high water holding capacity and can absorb up to 5 times its own weight of water. Biochar adsorbs very efficiently both organic molecules such as amino acids, fatty acids, proteins, and urea and also mineral compounds such as ammonium, ammonia, and nitrate. Used in litter, biochar locks in moisture and organic and inorganic nitrogen compounds. The nitrogen adsorption and the continuous drying of the litter deprive the microbial pathogens of their nutrient base and reduce toxic emissions of ammonia."

Turkeys and broiler chickens frequently suffer from leg weakness syndrome. and footpad dermatitis (pododermatitis). The causes of these inflammation reactions are multifactorial, but the main causes are high levels of ammonia (NH3) and overly damp litter. At the same time biochar is storing the moisture and nutrients, it's becoming more biologically active, and a better candidate for composting; "Carbon and nitrogen losses are significantly reduced and with them the emission of greenhouse gases (Steiner 2010). The fertilizer quality of the poultry manure increases strongly as a result of the biochar and the odour pollution can be reduced significantly, which increases the marketing potential of poultry manure."

[5] **Biochar Supplementation in Growing and Finishing Diets Winders;** T.; Freeman, C.; Mark, B.; Jolly-Breithaupt, M.; Hamilton, H.; MacDonald, J.; Erickson, G.; and Watson, A.,; 2019. Nebraska Beef Cattle Reports. 1031. http://digitalcommons.unl.edu/animalscinbcr/1031

[6] **The Use of Biochar In Cattle Farming;** Gerlach A, Schmidt HP: the Biochar Journal 2014, Arbaz, Switzerland; ISSN 2297-1114; www.biochar-journal.org/en/ct/9 ; August 2014

[7] **Biochar in poultry farming;** Gerlach H, Schmidt HP; Ithaka Journal 1/ 2012: 262–264 (2012) www.ithaka-journal.net; ISSN 1663-0521

5. A review of biochar research[8] includes details about biochar's ability to aid in manure management and the creation of high-quality compost as well as a feed.

> *"Biochar with its high porosity and large surface area can be an excellent adsorbent, retaining valuable elements (e.g., N, C, and S) that typically would be lost to the environment as unwanted pollutants, as well as other microelements in a composting mixture. High surface area also provides more spacious and aerated habitats for microorganisms, that promote microbial activity additionally stimulated by a relatively high content of less acidic, organic C that is available to the microorganisms, thereby having a strong positive influence on composting processes."*

6. Research[9] done at Washington State University found using biochar to enhance Anaerobic Digested dairy effluent found it accounted for a recovery of 32% of the phosphorus.

7. A comprehensive literature review[10] was conducted of 362 sources about the use of co-composted biochar (COMBI). The search was not limited to certain timespan. The oldest paper found was published in 2008 while the newest one was published in 2020 with the majority published in the last 5 years.

> *"The use of co-composted biochar, made by the addition of biochar at the beginning of the composting process, has greatly increased in agriculture during the last decade. There are more benefits of using the co-composting end product COMBI than using compost and biochar separately or the mixture of the two products.*
>
> *Biochar addition to composting is beneficial in the reduction of CH4 [methane] emission compared to without biochar addition, which is due to the reduced bulk density, better aeration, and gas diffusion, creating growth conditions suitable for methanotrophs (consuming CH4) while undesirable for methanogens (producing CH4) (Vandecasteele et al., 2016). Decline and increase of CO2 emissions after the addition of biochar were also reported.*
>
> *Biochar can serve as a protective habitat for microorganisms during composting. The micro- and macro-pores with a size comparable to bacteria provide shelter for them to proliferate with limited stresses from inhibitory compounds (e.g. NH3, H2S, and heavy metals), competitors such as pathogens, and environmental factors such as pH, leaching, and desiccation (Sanchez-Monedero et al., 2018)."*

8. In a study focused specifically on biochar use in poultry litter[11] there is further confirmation of the benefits cited above with specific details about why.

> *"The poultry industry produces abundant quantities of nutrient-rich litter, much of which is composted before use as a soil amendment. However, a large proportion of nitrogen (N) in poultry litter is lost via volatilisation during composting, with negative environmental and economic consequences. This study examined the effect of incorporating biochar during composting of poultry litter on ammonia (NH3) volatilisation and N retention. Biochars produced at 550°C from greenwaste (GWB) and poultry litter (PLB) feedstocks were co-composted with a mixture of raw poultry litter and sugarcane straw [carbon (C):N ratio 10:1] in compost bins. Ammonia emissions accounted for 17% of the total N (TN) lost from the control and 12–14% from the biochar-amended compost. The TN emitted as NH3, as a percentage of initial TN, was significantly lower (P < 0.05) i.e. by 60% and 55% in the compost amended with GWB and PLB, respectively, relative to the control. The proportion of N retained in the finished compost, as a percentage of initial TN, was 84%, 78% and 67% for the GWB, PLB and nil biochar control, respectively. Results showed that addition of biochar, especially GWB, generated multiple benefits in composting of poultry litter: decrease of NH3 volatilization, decrease in NH3 toxicity towards microorganisms, and improved N retention, thus enhancing the fertilizer value of the composted litter. It is*

[8] **A Review of Biochar Properties and Their Utilization in Crop Agriculture and Livestock Production;** K. Kalus, J. Koziel, and S. Opalinski; Appl. Sci. 2019, 9, 3494; doi:10.3390/app9173494

[9] **Biochar: Its Characterization And Utility For Recovering Phosphorus From Anaerobic Digested Dairy Effluent**; Streubel, J.; Dissertation, Washington State University, 2011; https://research.wsulibs.wsu.edu/xmlui/bitstream/handle/2376/2891/Streubel_wsu_0251E_10131.pdf?sequence=1

[10] **The roles of co-composted biochar (COMBI) in improving soil quality, crop productivity, and toxic metal amelioration** J. Antonangelo, X. Sun, H. Zhang; Journal of Environmental Management 277 (2021) 111443

[11] **Biochar lowers ammonia emission and improves nitrogen retention in poultry litter composting;** Waste Management · December 2016; DOI: 10.1016/j.wasman.2016.12.009

suggested that the latter benefit is linked to a beneficial modification of the microbial environment."

9. Research on the use of biochar to mitigate hog manure emissions[12] found significant reductions by using a pelletized biochar from corn stover pyrolyzed at 550°C.

> *"The efficacy of a pilot-scale biochar odor removal system (PSBORS) for removing 15 odorous VOCs was evaluated by placing it in a swine gestation stall continually treating the inside air for 21 days. All VOCs in the PSBORS effluent were below detection limit except for acetic acid. However, due to the very high odor threshold of acetic acid, its contribution to the odor would be minimal. It appeared that the CBC could be used to reduce both H2S and odorous VOCs with the potential of recycling the spent CBC for soil health improvement after using it for H2S and odor removal."*

10. In a 2017 to 2019 Washington State University study[13] looking at applications of compost where the biochar was mixed in prior to composting or the biochar was mixed into the finished compost before application to a variety of crops.

> *"Crop yield and soil health attributes were generally affected, and in many cases, significantly so, by the co-compost and compost plus biochar treatments. Co-compost and the compost plus biochar were typically observed to affect soil physicochemical properties beneficially, except in the case of bulk density. Our results suggest that blending compost with biochar optimizes the physical and chemical properties of each, but that this effect is somewhat dependent upon the native soil and crop.*[14]
>
> *While the project found generally beneficial results, but their cautionary notes are worth noting: The use of biochar as a soil amendment in cropping systems may be beneficial, but its use, and the intent of its use, need to be carefully considered and clearly defined. The differences we observed between biochar products (i.e., co-composted biochar or biochar alone) warrant this consideration, as growers using one or the other will likely see drastic differences in performance, and so, expectations for yield and soil responses should be appropriate to the product. Finally, it is important to note that data presented here is from one growing season which makes it difficult to draw conclusions and make confident statements. It should also be noted that because the characteristics of the biochar and compost impact chemical and biological processes, the use of different types of biochar or compost in these studies would be expected to yield different results."*

[12] **Mitigation of Acute Hydrogen Sulfide and Ammonia Emissions from Swine Manure during Three-Hour Agitation Using Pelletized Biochar;** Chen, B.; Koziel, J.A.; Lee, M.; O'Brien, S.C.; Li, P.; Brown, R.C.. Atmosphere 2021, 12, 825. https://doi.org/10.3390/

[13] **Integrating Compost and Biochar for Improved Air Quality, Crop Yield, and Soil Health;** D. Gang, D. Collins, T. Jobson, S. Seefeldt, A. Berim, N. Stacey, N. Khosravi, W. Hoashi-Erhardt; A report for The Waste to Fuels Technology Partnership 2017-2019 Biennium: Advancing Organics Management in Washington State; Sept 2019

[14] In general, the better the native soil, the less effect biochar will have.

11. In a study[15] looking at the pyrolysis temperature of biochar, specifically how it affects water holding capacity, the following highlights were presented:

- "Hydrophobicity was found in biochar from both feedstocks pyrolyzed at 400°C, but not at higher temperatures."
- "Available water content (AWC) of biochar increased with increasing pyrolysis temperatures, with optimal results obtained from grapevine cane at a pyrolysis temperature of 700°C, which had an AWC 23% higher than a typical clay type soil."
- "Pure biochars were superior in water retention performance to typical sandy soils, and so biochar amendment of these soil types may improve water holding"

12. An October 2020 article in Grapegrower & Winemaker Magazine[16] illustrates real-world benefits and experiences of using biochar and biochar enhanced compost on high-value crops. Some highlights:

- Biochar must be mixed with a nutrient dense solution such as compost or manure before application.
- One operator in NZ buries the biochar and compost mixture at a depth of around 40cm below most grass and weed roots, in a ratio of 1:10 biochar to compost, at 10 tons per hectare. It is also applied as a 50cm wide, up to 25cm high mulch strip beneath the vines, at 20 tons per hectare. The intent of the second application is two-fold; biochar acts as a weed suppressant and it maximizes the potential CEC [Cation Exchange Capacity, potential bonding of nutrients and minerals to the biochar surface] of the soil.
- The other benefit studied as part of the trial was the water holding capability of biochar as a means of managing irrigation demand. The porous structure of biochar aids water retention and data from trials in European vineyards estimate biochar is capable of retaining up to five times its weight in water. At the conclusion of the Central Otago [NZ] trial, an increase in plant available water of 30% was recorded for the biochar application.
- The water retention capabilities of biochar have previously been studied at The University of Adelaide. The results, published in 2019, showed increased available water content in biochar burned at higher temperatures. Grapevine canes burned at 700˚C produced biochar with available water content 23% higher than a typical clay soil. If increased access to water can be obtained beneath the soil using biochar, the demand for irrigation and the potential leaching of nutrients at the site of irrigation are both reduced, lowering irrigation costs and optimizing water management.
- The results were published in June 2020 and the project was led by Professor Jim R. Jones, who said, 'biochar delivers far-and-away the best environmental outcome. Going down the biochar route means the [viticulture] industry potentially has the opportunity to offset the emissions from all other parts of the production and supply chain."

[15]**Pyrolysis Temperature Effects on Biochar–Water Interactions and Application for Improved Water Holding Capacity in Vineyard Soils;** J. Marshall, R. Muhlack, B. Morton, L. Dunnigan, D. Chittleborough, C. Kwong; Soil Syst. 2019, 3(2), 27; https://doi.org/10.3390/soilsystems3020027

[16]**Biochar in the vineyard: building a foundation for sustainability,** S. Madden-Grey; https://anzbig.org/wp-content/uploads/2020/10/Simone-Madden-Grey-GW-Biochar-October-2020.pdf

13. Another meta-analysis[17] of biochar research looked at biochar's effects on crop yields from research published between 1998 and 2017. The analysis concluded: "…that biochar addition to soil generally produced positive effects on crop yields." With the caveat: "Yield responses have been found to be relatively larger in low-pH and coarse textured soils, and with the application of nutrient-rich biochars (Biederman and Harpole, 2013; Jeffery et al., 2011; Liu et al., 2013), or in soils with small CEC and low levels of organic carbon (OC) content (Crane-Droesch et al., 2013)."

14. A cautionary study[18] of using biochar in soils summarizes 259 studies from 15 years of research. The review summarizes the possible adverse effects with these highlights:

- Adverse effects may arise due to changes in soil properties upon biochar addition.
- Soil organisms, mostly earthworms, suffer from biological adverse effects of biochar.
- Several unfavorable soil-biochar combinations were identified.
- A holistic approach is needed to reveal all possible, long-term adverse effects.

The paper concludes with tables linking the adverse effects on soil microorganisms, invertebrates, and general potential negative effects of biochar in soils, all linked to the original research.

15. Anaerobic Digestion (AD) is a growing solution to manure management with the added benefit of energy production. While AD is not covered in this report, this recent paper highlights the benefits of using biochar.[19]

> *"Biochar recently gained attention as an additive for anaerobic digestion (AD). This work aims at a critical analysis of the effect of six BCs, with different physical and chemical properties, on the AD of mixed wastewater sludge at 37°C, comparing their influence on methane production and AD kinetics. The physic-chemical properties of biochar (specifically, hydrophobicity and morphology) showed a key role in improving the AD of mixed wastewater sludge."*

[17]**Biochar effects on crop yields with and without fertilizer: A meta- analysis of field studies using separate controls;** L. Ye, M. Camps-Arbestain, Q. Shen, J. Lehmann, B. Singh, M. Sabir; Soil Use Management, 2020;36:2–18; DOI: 10.1111/sum.12546

[18]**A critical review of the possible adverse effects of biochar in the soil environment;** M. Brtnicky, R. Datta, J. Holatko, L. Bielska, Z. Gusiatin, J. Kucerik, T. Hammerschmiedt, S. Danish, M. Radziemska, L. Mravcova, S. Fahad, A. Kintl, M. Sudoma, N. Ahmed, V. Pecina; Science of the Total Environment 796 (2021) 148756; https://doi.org/10.1016/j.scitotenv.2021.148756

[19]**Addition of Different Biochars as Catalysts during the Mesophilic Anaerobic Digestion of Mixed Wastewater Sludge** Chiappero, M.; Cillerai, F.; Berruti, F.; Mašek, O.; Fiore, S.; Catalysts 2021, 11, 1094; https://doi.org/10.3390/catal11091094

Section 2.

For Livestock Producers: A Breakout Section about Using Biochar with Livestock

Section 2. For Livestock Producers: A Breakout Section about Using Biochar with Livestock

This section is addressed to livestock producers considering using biochar in their operations specifically, either as a feed additive or in the management of the manure. After a review of the why and how to use biochar effectively, there is a detailed look at biochar and how to understand it's function.

Biochar can address these livestock grower's needs:

- Improve animal health
- Better manure management
- Accelerated composting
- Soil application:
    - o Increase water retention
    - o Increase soil carbon
    - o Nutrient release leveling
    - o Soil structure management
    - o Soil biota improvement
    - o Soil contamination mitigation

Potential uses of biochar:

- As a feed additive
- As a manure management tool to reduce methane, N, and CO^2 release
- To enhance composting operations
- Sanitary method of disposing of bedding, litter, or manure (as feedstock for biochar) for closed loop management.

Benefits of biochar use include improved animal health, potential for increased livestock gain and/or yield, higher retention of volatiles in manure (ammonia, methane, and nitrogen compounds specifically), improvement in compost operations and, when ultimately applied to soils, improved crop yields, improved water retention/reduced irrigation costs, increased soil carbon, and long-term carbon sequestration.

Biochar Application

- Bulk biochar is typically supplied in a walking floor trailer or super sacks. It can also be purchased in smaller packaging for a price premium.
- Used as a feed supplement, it can be added to the bulk feed mix, top dressed, or fed free choice as a 'mineral' supplement. Feed rates have been tested at 0.25 to 5%, with the optimal rate appearing to be 0.3%.
- Biochar used in compost has been added at rates ranging from 10-25% by volume. The use in bedding should be at a lower ratio (about half) to account for the decomposition of the organic matter during composting. However, adding biochar to a manure pile should be done prior to composting and at the higher rate.

Costs and Resources–Bulk biochar prices have been relatively stable at about $200 per cubic yard; however, the cost is dependent on the specifications, any regulatory procedure costs, and shipping distance. A list of biochar producers is available at the US Biochar Initiative's website to aid in finding suppliers: Directory by State | US Biochar Initiative (biochar-us.org/directory)

A special note about using biochar as a feed additive in the US:

In the US, the FDA regulates feed additives for livestock and approves biochar sold interstate as a feed additive on a case-by-case basis.[20] There are currently suppliers of biochar-for-livestock feed which are approved at the state level however many states follow the FDA approval process. Firms interested in using or selling biochar will need to check with their state feed regulation agencies to determine their best course of action. There is an exception for the use of activated charcoal from organic feedstocks (in mammals only) detailed at the end of Appendix A.

No approval is required for non-feed uses of biochar. In either event, the analysis of the biochar is important. The feedstock for the biochar needs to be clean of any potentially harmful contaminants and consistent. The testing requirements for FDA approval as well as the European Biochar Certificate are provided in Appendices A and B as information as well as providing a useful perspective on what to look for in a quality feed-grade biochar.

[20] An exception is California which has its own approval process allowing out-of-state producers to supply CA livestock operations. CA approval: CDFA - IS - Feed, Fertilizer and Livestock Drugs Regulatory Services (ca.gov)
Registration Aid (PDF) https://www.cdfa.ca.gov/is/ffldrs/pdfs/BiocharFlowchart.pdf

Potential for Carbon Credits

The developing carbon credit market will have a significant effect on the economics of biochar use. There are clear advantages for livestock producers to market their "greening" efforts to reduce methane and carbon dioxide emissions by using biochar, but it offers the opportunity to profit from the long-term sequestration of carbon, too. This is especially true for users at volume and for operations that use the biochar-laden manure on their own land. Carbon markets are becoming more established as a climate change mitigation strategy and biochar is an established product with evaluation criteria in place. Current brokers in the US are Verra[21] and Puro,[22] but other systems are coming online so researching this financial avenue is advisable.

Understanding Biochar

The first step in acquiring biochar for a feed or bedding additive is to know what to specify. Figure 2 illustrates those biochar specifications. For animal consumption, the biochar feedstock has to be safe. There can be no toxic residues, so the feedstock used to make the biochar has to be a "pure" organic substance like woody material (not construction debris), grasses, or clean agricultural residues. This initial "purity" makes the biochar, once it's passed through the animal, more valuable as a soil amendment, too. One of the most highly recommended (and sought after) biochar products for agricultural soil amendment is a biochar-compost mix. In a livestock operation, manure that includes biochar becomes an important feedstock for high-quality compost, and as such, offers livestock operations a value-added opportunity.

It cannot be stressed enough that not all biochars are the same. It is important to understand what kind of biochar is needed to address specific end uses. Figure 2 illustrates generally what to look for in a biochar. Commercially available biochars can be evaluated by looking at the lab test results. A good reference for biochar testing standards and biochar properties is available at the International Biochar Initiative website.[23]

Using Figure 2 to understand biochar properties better, a biochar made above 450°C will provide desirable characteristics—not too much liming effect, good CEC (cation exchange capacity), decent surface area expansion, and acceptable carbon recovery. To be certain of the characteristics, a lab analysis is essential—either provided by the producer or, ideally, from an independent lab. The carbon recovery line needs more explanation: the pyrolyzed carbon comes in two forms: stable (also referred to as recalcitrant) and labile (or reactive). The stable carbon fraction will remain in the soil for a long time (decades to millennia). The labile fraction will react with other elements in the soil and ultimately convert to CO2 within a few years. The higher temperature chars (with the most surface area) tend to have higher proportions of stable carbon. This is an important consideration for soil management planning, but also if carbon credits are being sought. These markets are becoming more established as a climate change mitigation strategy and should be included in any economic evaluation.

The graph for Figure 2 is for a specific hardwood, but for comparison, the graph of other hardwoods will be very similar. A biochar derived from softwood will look slightly different, but grass or manure-based biochars will be very different.[25] Getting input from a soil's expert is advisable; Extension Agents from your local Land Grant University are a first-stop for a referral to those resources if you don't already have a consultant.

Photo credit: High Plains Biochar

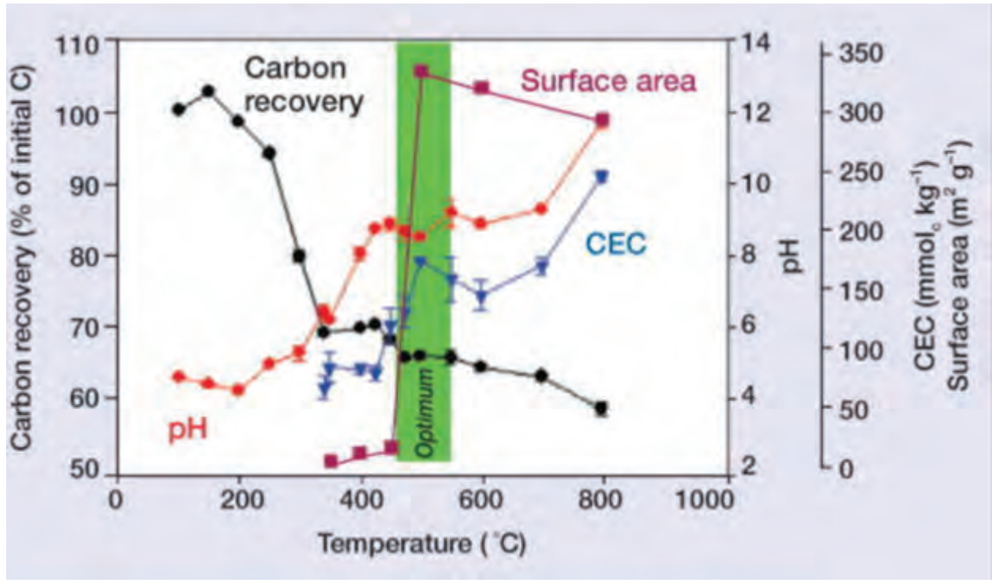
[21] Verra, voluntary carbon market projects: https://verra.org/voluntary-carbon-markets/

[22] Puro Earth, carbon removal marketplace: https://puro.earth/

[23] International Biochar Initiative, biochar resources: https://biochar-international.org/resources/

[25] **Analyses of biochar properties;** Allaire SE, Lange SF, Auclair IK, Quinche M, Greffard L; (2015); CRMR-2015-SA-5. Centre de Recherche sur les Matériaux Renouvelables, Université Laval, Québec, Canada

Figure 2. Change in Biochar Characteristics with Temperature



Lehmann, J. (2007), Bio-energy in the black. Frontiers in Ecology and the Environment, 5: 381-387. https://doi.org/10.1890/1540-9295(2007)5[381:BITB]2.0.CO;2

Photo credit: High Plains Biochar

Section 3.

Livestock Producers' Experiences using Biochar

Section 3.
Livestock Producers' Experiences using Biochar

This section explores recent field trials and experiences of various livestock growers who are using biochar. Formal domestic research on biochar as a cattle feed additive is limited, however the holistic use of biochar with livestock (as a feed, as a manure management strategy, and as soil enhancement) is supported by the reviewed literature.

Examples of biochar as an animal feed in the US are currently limited by the need for FDA approval for the interstate sale of biochar. There are however, livestock producers with approved in-state biochar sources using it as a feed, and there are more widespread producers using biochar as a bedding amendment, compost enhancer, or for manure management. The best indicator of the future of biochar in the U.S. as a feed additive comes from the experience of users in the European Union, where biochar is approved as a feed additive and which are documented in in Section 1, Articles 1 and 3.

There are beef cattle, dairy cattle, small ruminant, and poultry producers using biochar with their livestock. Since many are using the biochar as a feed additive "off label" they've agreed to share experiences only anonymously and are included without attribution:

A Colorado beef cattle producer is using ¼ cup daily per head under the Organic Exemption noted at the end of Appendix A which permits feeding activated charcoal to temper feeds containing aflatoxins or molds. He's seen an elimination of bloat without resorting to chemical treatments, resulting in better rumen function, higher feed conversion efficacy, and more consistent weight gain. The source of the char is a fine-grained biochar made from hardwood sawdust, supplied by the truckload, and mixed with the feed ration.

A Southwestern US dairy operator shared:

> *When starting to use it in my cow herd, I added ¼ cup/cow /day in a TMR [ration mix] and instantly the cows went through what seemed like a body cleanse. Their manure became looser for a couple days and then thickened up again. I can now feed higher protein hay and they don't get so loose. The cows are much healthier and it is much easier to maintain their body weight. I believe that they are not needing to fight off the toxins and have more energy for body maintenance and production. We had an increase of approximately 10% in milk and 1% in butterfat and a decrease in about 7% in feed consumption. Their mineral consumption greatly increased for about 2 months. Then it decreased to less than what they were consuming before I started Biochar.*

A pilot project included an Organic poultry producer in VA using biochar in litter—which the chickens will eat coincidently—for the ammonia reduction benefit, but also illustrating the practices' holistic potential:[26]

> *"We import over a million tons of grain a year and are a hot spot for nutrient leakage into the Chesapeake Bay. Phosphorus even shows up in ground water because soils are often saturated. Poultry litter and dairy manure are our best options for nutrient loading in biochar. Right now, most of my production is ground to a 2mm average diameter and used in the bedding in poultry houses for organic chicken production. The resultant litter enriched with biochar is approved for use on organic farms."*

The lead author of this report uses biochar in the bedding of both sheep and poultry to reduce ammonia levels and to incorporate the char into the eventual compost. The biochar-compost mix is used for orchard, horticultural, and row crops, as well as broadcast on pastures. The mix is incorporated into the soil by disking or tilling. Preliminary results from a 2019 to 2022 Biomass Research and Development Initiative (BRDI) project,[27] which include plots on our farm, indicate a notable increase in soil carbon and a corresponding increase in retained nitrogen compounds.

Dr. Andrea Watson at the University of Nebraska-Lincoln cited in Article 2 of Section 1, has also trialed biochar placed directly in feedlot paddocks. They found the biochar enhanced nitrogen enrichment of the manure, aiding crop fertilization, with no negative effects on the animals. This video describes the project, their experiences, and the broader context of the biochar's role in land and forest management as well as in the specific livestock application: Biochar and Livestock-University of Nebraska

[26] This project is in collaboration with Dr. Wayne Teel, a Professor at James Madison University. Preliminary data shows reduced ammonia levels throughout the growing period, but is unpublished, awaiting replication and review.

[27] **Life-Cycle Assessment of Biochar in Agricultural and Forest Ecosystems: Effects on Production, Soil Fertility, and Economic Impact;** NIFA2018-10008-28583

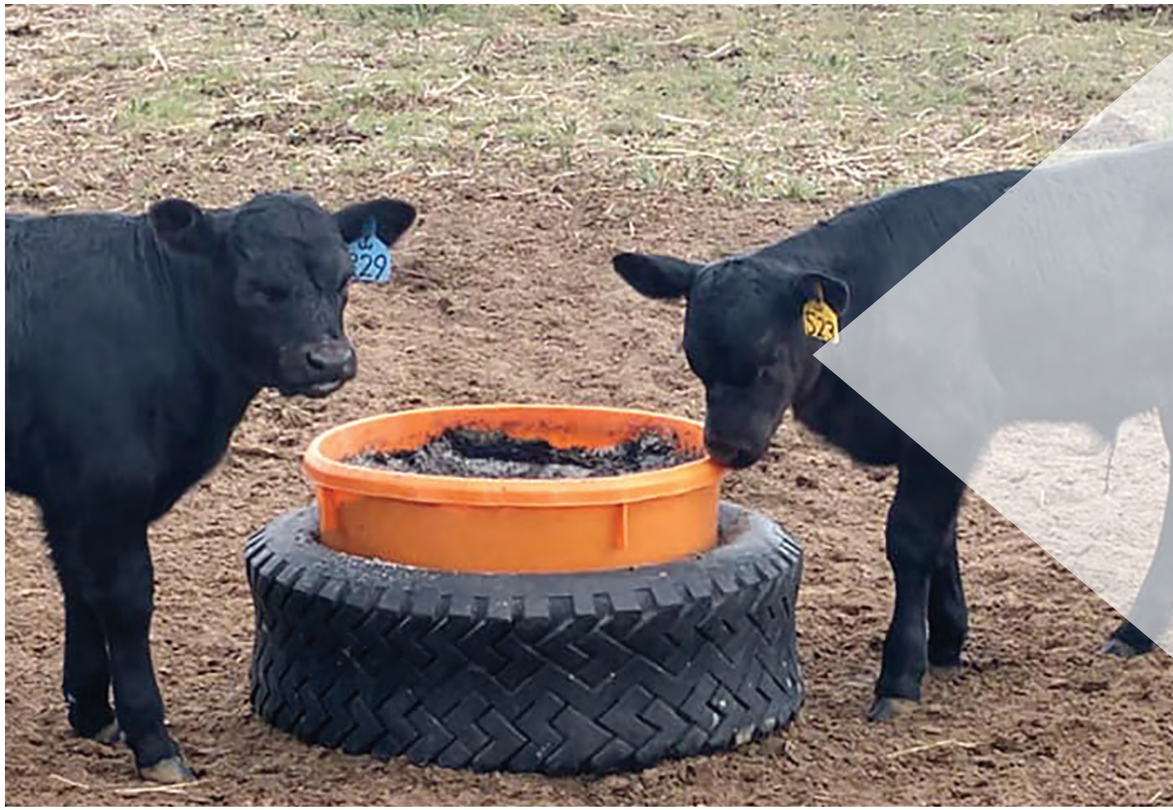


Photo credit: High Plains Biochar

Section 4.

A Breakout Section about the Market Potential for Biochar in the Livestock Industry

Section 4. For Biochar Producers:
A Breakout Section about the Market Potential for Biochar in the Livestock Industry

Biochar has potential application in the livestock industry as either a feed supplement or manure management strategy. As a feed supplement, it can support animal health and productivity, and used in manure, it retains nutrients, controls odor, and accelerates composting. The resulting benefit from the latter use also provides a rich soil amendment source that can be applied to crop and rangeland, improving many soil health metrics.

The market for biochar used within the livestock industry is significant when looking at both animal feed additives and as a bedding/manure management additive. Figure 3 shows the 2019 feed amounts going to different segments of the animal feed market. The total US animal feed requirements (less pets, horses, and aquaculture) was 266M tons, so for a 1% market penetration, biochar would be added to 2.7M tons of feed. At a 3% rate,[28] that's 81,000 tons of bone dry[29] biochar which, at 200lbs/cubic yards, yields 810,000 cubic yards.[30]

Biochar is also beneficial as a bedding additive. For example, poultry operations have bedding for most growing operations and ammonia is a widespread problem. The build-up of ammonia leads to health problems and increased mortality which biochar has proven effective in reducing. A 1% penetration of the poultry bedding market (using a 10% application rate[28] by weight to the estimated 2M Ton manure load) would require 200T or 2010CY of biochar annually. [31]

If we look at other species, a feedlot steer will produce 65 pounds of manure per day[32] (with 94 million (M) head in the US in 2020,) a 300-cow dairy will generate 8000 gallons of manure and wastewater daily[33] or about 21 tons per year per head (with 10M head). Pigs will produce an estimated 1600 pounds of manure per year[34] per head (with

[28]Application rate derived from field trials and research projects cited and explored in this document.

[29]**Moisture Content Effect**: If the bulk density of biochar is 8lbs/ ft3 and water is 62.4lbs/ ft3, there will be 108lbs of water in a 50% moisture content mix. The water component would take up only 1.7 ft3 or 6.3% of the volume. For consistency, biochar-by-volume has been used unless noted.

[30]**Calculation details:** Biochar is typically 7-9lbs/CF dry; using the 8lbs median yields 216lbs per CY.

[31]1500lbs. manure/100K birds annually. US production in 2019 was 9.22M broilers, 229K turkeys with approximately four times the manure load, and 3.6M Layers= total of 13.4M birds yielding approximately 201K tons of manure. At a 10% application rate and 1% market penetration= 200 tons annually or 2010 CY.

[32]Beef Cattle Feedlots & Manure Management by LPE Learn Center - Exposure

[33]https://www.clemson.edu/extension/camm/manuals/dairy/dch3a_04.pdf

[34]https://www.clemson.edu/extension/camm/manuals/swine/sch3a_03.pdf

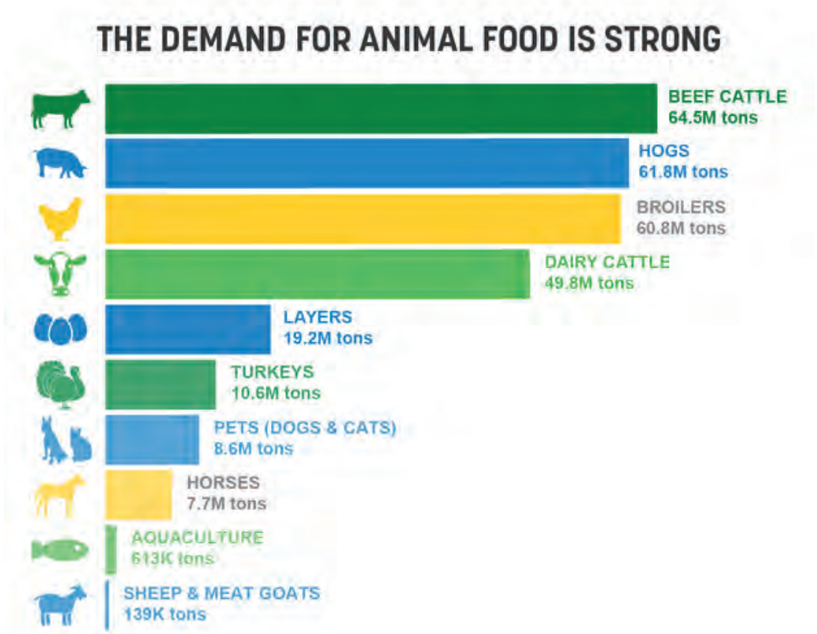
[35]Sheep 201: Nutrient management on a sheep farm (sheep101.info)

34M head), and market lambs will generate about 4 pounds of manure[35] each (at 3.2M head). Aggregating manure production of all food and fiber animals, there are approximately 1.4B tons of animal manure generated in the US annually. Using a 1% market penetration and a 10% application rate by weight, there would be a need for 1.4M tons of biochar annually.

Since the cattle business is the largest user of feed and the largest generator of manure, the following spotlight on that market segment is included to provide a sense of the market segmentation and opportunities which arise from understanding it better:

> *From the USDA Economic Research Service's June 2021 report: on the beef market:*
>
> *Cattle production is the most important agricultural industry in the United States, consistently accounting for the largest share of total cash receipts for agricultural commodities. In 2021, cattle production is forecasted to represent about 17 percent of the $391 billion in total cash receipts for agricultural commodities.*
>
> *Cattle feeding operations are concentrated in the Great Plains and they are also located in parts of the Corn Belt, Southwest, and Pacific Northwest. Feedlots with less than 1,000-head capacity make up most of U.S. feedlot operations, but they market a relatively small share of the fed cattle. Conversely, although feedlots with 1,000-head-or-greater capacity are less than 5 percent of total feedlots, they market 80 to 85 percent of fed cattle. Feedlots with a capacity of 32,000 head or more market around 40 percent of fed cattle. The industry continues to shift toward a small number of very large, specialized feedlots focused on raising a high-quality cattle for a particular market, such as markets requiring cattle not treated with hormones and not fed beta agonists. NASS provides monthly Cattle on Feed reports.*

Figure 3 2019 Animal Feed Consumption[36]



In 2019, nearly 284 million tons of animal food were consumed by domestic livestock and pets.

[36] American Feed Industry Association statistics: https://www.afia.org/feedfacts/feed-industry-stats/animal-food-consumption/

The total need for biochar for livestock-use based on a 1% market penetration is roughly 1.5MTPY or 150MCY with 99.4% of that for manure management. At a bulk price of $200/CY, this equates to $30B in of compost with biochar, there is significant market potential with both compost operations and with VMC's who're specifying the horticultural management of hundreds of thousands of acres in CA.

Livestock industry applications will typically require bulk volumes of product either by truck or supersacks. Smaller-scale livestock operations utilizing biochar as a feed supplement may benefit from smaller unitized bags.

Costs Analysis– Besides the basic cost of producing the biochar, there will be additional costs associated with the approval process if going to a feed product. There is considerable testing to qualify for certification, and the feedstock will need to be maintained fairly standardized which may entail additional costs. Biochar produced for non-feed applications will need to be from "clean" feedstocks, and its analysis should be coordinated with the end user like similar agriculture uses, but otherwise is a relatively stock product.

Biochar's Competition comes primarily from:

- Other feed components and supplements
    - o Livestock producers are extremely sensitive to feed costs. There will be significant pressure from producers to justify the cost of biochar versus other constituents of the mix including minerals, digestive additives, and prescribed drugs.
- Synthetic and organic fertilizers
    - o In soil applications—where bedding, litter, and manure ultimately end up—biochar is competing with fast acting targeted chemical products.
    - o Organic producers offer similar product lines to amend soils, but they're typically "wide spectrum, low intensity" products against which biochar-enhanced products may be more competitive. Biochar is relatively easy to list as an organic material.[37]
    - o Biochar has proven effective as a mitigant of soil effects from the use of synthetic chemical applications, and in some cases with some herbicidal and fungicidal capacity itself.
- Compost
    - o Compost is one of the most popular supplemental materials used with high-value crops (i.e., viticulture and organic crop). Biochar is a proven and cost-effective supplement to compost.

[37]The Organic Materials Review Institute (OMRI) is an international nonprofit organization that determines which input products are allowed for use in organic production and processing. Get Listed | Organic Materials Review Institute (omri.org)

Appendix A FDA Regulations and Contact information

Substances in animal food must be either approved food additives described in Title 21 Code of Federal Regulations (21 CFR) part 573 (21 CFR 573) or be GRAS for an intended use in animal food. In addition, staff at FDA's Center for Veterinary Medicine (CVM) serve as the scientific reviewers for ingredient definitions in the Official Publication (OP) of the Association of American Feed Control Officials (AAFCO).

Biochar is a type of charcoal. There is no food additive regulation for charcoal, and charcoal has not been recognized as generally recognized as safe (GRAS) for a use in animal food. Charcoal was formerly listed as a feed term (not an accepted feed ingredient) in the AAFCO OP. In 2010 AAFCO voted to delete charcoal from the list of official feed terms, moving it to the withdrawn section of the OP. This change was first reflected in the 2012 OP of AAFCO. Currently, no food additive regulation, no feed term, and no feed ingredient definition exist for any type of charcoal, meaning no acceptable animal food use has been established for "charcoal" in general.

Author's Note: This paragraph explains the FDA's current position on biochar:

Wood charcoal has been documented to contain dioxins, furans, and heavy metals. Therefore use of charcoal in animal food would require review of data to demonstrate its safety for the intended use. Before charcoal could be used in animal food, data are needed to demonstrate that it can be produced without contaminants, such as dioxins, furans, and heavy metals. Data are also needed to establish that feeding wood charcoal to livestock has utility for an appropriate food use and would not result in tissue residues impacting human food safety. These reviews could be accomplished through the animal food additive petition regulatory pathway.

Further background:

Regulatory Structure for Animal Foods and Drugs in the United States

In the United States, substances intended for use in animal foods are generally considered to be either animal foods or animal drugs. The regulatory classification of a substance relies on its intended use. Claims for substances that are regulated as animal foods are limited to those that can be attributed to the substance's "food" properties, which the courts in the United States have defined as being related to the provision of nutritive value, taste, or aroma. If claims indicate that a product or substance is intended to mitigate, treat, prevent or cure diseases, the substance is regulated as an animal drug in the United States. Additionally, a substance may also be regulated as a drug if its intended use is to affect the structure or function of the body in a manner not related to the provision of nutrients, taste, or aroma.

The primary food law in the United States, the Federal Food, Drug, and Cosmetic Act (the FD&C Act), defines food as "articles used for food or drink for man or other animals." Any substance intentionally added to an animal food must be either an approved food additive as listed in part 573 in Title 21 of the Code of Federal

Regulations (21 CFR 573) or a substance that is generally recognized as safe (GRAS) for an intended use, including those listed in 21 CFR 582 and 584. Also, in coordination with state feed control officials, CVM recognizes ingredients in the Official Publication (OP) of the Association of American Feed Control Officials (AAFCO) as being acceptable for use in animal foods.

Food Additive Petition Process

The federal regulations that apply to food additives used in animal food are published in 21 CFR 571 along with regulations that describe the food additive petition (FAP) process. Listed below are the types of data and information that should be submitted by the petitioner and the required format for the petition itself. While the actual content may vary from petition to petition, depending primarily on the composition of the food additive and its intended use, each of the following subject areas should be addressed:

a. human food safety

b. target animal safety

c. environmental impact

d. utility (intended physical, nutritional or other technical effect)

e. manufacturing chemistry and controls

f. labeling (cautions, warnings, shelf life, directions for use)

g. proposed regulation.

FDA cannot approve a FAP if our evaluation of the data fails to establish that the proposed use of the additive, under the conditions of use to be specified in the regulation, will be safe. CVM published a guidance document about the food additive petition process, Guidance for Industry # 221, Recommendations for Preparation and Submission of Animal Food Additive Petitions, which is available at:

- http://www.fda.gov/downloads/AnimalVeterinary/GuidanceComplianceEnforcement/GuidanceforIndustry/UCM367746.pdf

Please note that data obtained outside of the United States in support of a FAP may be acceptable provided the conditions of testing simulate feeding practices in the United States. Also, please ensure that if material written in a foreign language is submitted, a complete translation in English is provided. All supporting documents and photocopies submitted to CVM should be legible. The statutory time frame for the review of a FAP by CVM is 90 days as stated in 21 CFR 571.100; however, this time frame can be extended to 180 days.

Generally Recognized as Safe (GRAS) Notification Program

Under sections 201(s) and 409 of the FD&C Act, and FDA's implementing regulations in 21 CFR 570.3 and 21 CFR 570.30, the use of a substance may be GRAS either through scientific procedures or, for a substance used in food before 1958, through experience based on common use in food. Under 21 CFR 570.30(b), general recognition of safety based upon scientific procedures requires the same quantity and quality of scientific evidence as is required to obtain approval of a food additive. General recognition of safety through scientific procedures must address safety for both the target animal and for humans consuming human food derived from food-producing animals and is based upon the application of generally available and accepted scientific data, information, or methods, which ordinarily are published, as well as the application of scientific principles, and may be corroborated by the application of unpublished scientific data, information, or methods. Under 21 CFR 570.30(c) and 570.3(f), general recognition of safety through experience based on common use in food requires a substantial history of consumption of a substance by a significant number of animals of the species to which the substance is intended to be fed (and, for food producing animals fed with such substance, also means a substantial history of consumption by humans consuming human foods derived from those food-producing animals). The time frame for the evaluation of a GRAS notice by CVM is 180 days as stated in 21 CFR 570.265; however, this time frame can be extended to 270 days. The information required to be included in a GRAS notice by the notifier is described in 21 CFR 570.220 through 570.255. CVM published a guidance document about the GRAS provision in the FD&C Act, Guidance for Industry: Frequently Asked Questions About GRAS for Substances Intended for Use in Human or Animal Food, which is available at:

- https://www.fda.gov/downloads/Food/GuidanceRegulationGuidanceDocumentsRegulatoryInformation/UCM525233.pdf .

If firms intend to participate in the GRAS notification program, the following information must be included in the Notice:

a. Statement that you are submitting a GRAS notice and administrative information

b. Describe the intended conditions of use of the notified substance; identify the animal foods to which it will be added; the levels of use in such foods; the animal species; and the purposes for which the substance will be used

c. Statutory basis for conclusion of GRAS status

d. Statement that premarket approval as a food additive is not required

e. Statement of your view as to whether any of the data and information relied on in the GRAS notice are confidential, i.e., exempt from disclosure under the Freedom of Information Act

f. Certify that the GRAS notice is a complete, representative, and balanced submission

g. Publicly available scientific data and information that addresses

1. Identity, method of manufacture, specifications, and physical or technical effect
2. Target animal and human exposures
3. Self-limiting levels of use
4. Narrative that provides the basis for your conclusion of GRAS status
5. List of supporting data and information

A more detailed description of this information is available at the following website:

- http://www.fda.gov/AnimalVeterinary/Products/AnimalFoodFeeds/GenerallyRecognizedasSafeGRASNotifications/ucm192219.htm

AAFCO Ingredient Definition

An AAFCO feed ingredient definition for publication in the OP may be established for a substance with no apparent safety concerns for the target species, people consuming animal products from animals fed diets containing the substance, or the environment when used in animal food. To engage in this process, stakeholders should contact the appropriate AAFCO investigator directly with regard to submission of information relating to a proposed feed ingredient definition for a substance. A list of AAFCO investigators is available on the AAFCO internet site (http://www.aafco.org/Regulatory). The AAFCO investigator will in turn ensure that the submission is complete and may seek the assistance from CVM as a scientific consultant for review of the ingredient definition package. After CVM reviews the submitted information, a recommendation of whether (or not) to include the proposed ingredient into the AAFCO OP is communicated to AAFCO. Firms should work with AAFCO, if they intend to pursue an AAFCO feed ingredient definition. CVM's role in the AAFCO feed ingredient definition process is to serve as a scientific advisor and to provide our recommendations to AAFCO. There is currently a Memorandum of Understanding between FDA and AAFCO describing the role of each organization in the feed ingredient definition process. This memorandum can be accessed at:

- https://www.fda.gov/aboutfda/partnershipscollaborations/memorandaofunderstandingmous/domesticmous/ucm439961.htm

If firms intend to proceed with the AAFCO feed ingredient definition process, then they may submit the following information to AAFCO:

a. firm and contact person

b. summary of the request

c. proposed definition

d. rationale for request

e. description of the ingredient

f. historical regulation of the ingredient

g. manufacturing

h. purpose of the ingredient

i. use limitations (if any)

j. data to support intended use

k. safety assessment

l. statement for risk for target animals

m. statement of risk related to human food

n. statement of environmental safety

o. list of cited literature

p. proposed labeling.

We note that there is no statutory time frame for the review of an AAFCO ingredient definition request. Other agency priorities impact the review time of AAFCO new ingredient definition requests, and because these priorities change frequently, we cannot provide a time frame for completing an AAFCO new ingredient definition review. More information about the AAFCO ingredient definition process is available at:

- http://www.aafco.org/Regulatory/Committees/Ingredient-Definitions

CVM encourages firms to consult with us before filing a FAP or GRAS notice, which could include requests for meetings or teleconferences to facilitate the development of the information needed for a FAP or GRAS notice, particularly for firms that do not have previous experience preparing these submissions

From correspondence with FDA's Dr. Edwards, asking about states are approving the sale of biochar for animal feed:

To date, biochar has not been approved by FDA. Individual states have feed control officials in addition to those at the federal level. At the federal level, we regulate animal feed in interstate commerce. This includes materials to make the feed and the sale/distribution of the feed. Sale of animal feed is generally regulated under the same provisions, no matter the size of the operation. Some requirements may be different depending on the size of the manufacturer, but they are all responsible for producing safe feed.

If a firm wants to submit data and information for a regulatory approval, we would suggest they first contact us to help them with the data requirements.

I may have mentioned this before, but activated charcoal is utilized in emergency situations by veterinarians for toxic substances, but is not approved for food use in animals.

David Edwards, PhD
Director, Division of Animal Feeds

Center for Veterinary Medicine
Office of Surveillance and Compliance
U.S. Food and Drug Administration
Tel: 240-402-6205
david.edwards@fda.hhs.gov

Note on A Rule by the Agricultural Marketing Service for an "exception" to the use of activated charcoal, published in the 12/27/2018 Federal Register, which went into effect on January 28, 2019:

ACTIVATED CHARCOAL

This final rule adds activated charcoal to § 205.603(a) for use in organic livestock production. Paragraph (a)(6) is amended in § 205.603 to read as follows: Activated charcoal (CAS # 7440-44-0)—must be from vegetative sources. After the effective date of this final rule, organic livestock producers may use activated charcoal as a therapeutic treatment on an as-needed basis with mammalian livestock in cases of suspected ingestion of toxic plants and control of diarrhea caused by moldy silage. Synthetic forms of activated charcoal derived from other non-vegetative sources continue to be prohibited in organic livestock production. AMS has reviewed and agrees with the NOSB recommendation that activated charcoal be allowed for use in organic livestock production. AMS received comments on the proposed rule for amending activated charcoal onto § 205.603 .[38]

[38]7 CFR § 205.603 - Synthetic substances allowed for use in organic livestock production. https://www.federalregister.gov/documents/2018/12/27/2018-27792/national-organic-program-amendments-to-the-national-list-of-allowed-and-prohibited-substances-crops#p-18

Appendix B: European Union Certification for Biochar as an Animal Feed

Biochar for use as a feed additive Labeled: EBC FEED grade

Biochar is a traditional feed additive that was often used to treat digestive problems of livestock. Since 2010, biochar is increasingly used as an additive to daily feed mixtures. The use of biochar (i.e. vegetal carbon) as a feed additive is authorized by the EU-Feed Regulation (Parliament, 2011). According to EU-Regulation 2002/32/EC of 7 Mai 2002 on undesirable substances in animal feed (Parliament, 2002) and EU-Regulation 396/2005 of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin (Parliament, 2002), analytical parameters, methods, and thresholds for biochar used as feed are different than those used in soil. Parameters and analytical methods for the EBC-certification of biochar as animal feed additive (EBC FEED) are outlined below.

The permissible test methods as well as the analytical methods for the individual parameters are detailed in Chapter 14.

9.1 Precondition for EBC FEED grade certification

Biochar can only be certified under EBC FEED when all conditions for EBC premium quality are met and the production was accordingly certified.

9.2 Biomass – only biochar made from natural and untreated wood is permissible. Although a large number of scientific studies have shown positive effects of biochar feed on animal health (Schmidt et al., 2016; Toth & Dou, 2016), there are few studies on the specific effects of different types and qualities of biochar on digestive activities and animal welfare in general. There are many years of experience in the use of wood-biochar (i.e. charcoal) and activated carbon, but not of biochar from other biomass such as straw, pomace or green waste with higher ash contents. Therefore, it can currently not be ruled out with certainty that biochars from more ashy non-woody biomass precursors could have adverse effects on animal health when used as a feed additive on a long-term basis. Based on the precautionary principle, only biochar from natural, untreated trunk wood is currently permitted for use as animal feed. The EBC follows closely the scientific literature on biochar feed and will include other biomass feedstock as soon as safe and reliable data can be presented.

9.3 Carbon content > 80% of dry matter (DM)

The Carbon content of biochar for use as animal feed must contain at least 80% carbon (dry matter).

9.4 Heavy metals

According to feed regulations, the contents of the heavy metals including arsenic, lead, cadmium and mercury must be stated. Their limits differ from those for EBC premium quality. The use of biochar as feed is based on the following thresholds to be calculated on 88% of the dry matter content: arsenic: 2 mg kg-1; lead: 10 mg kg-1; cadmium 1 mg kg-1 and mercury: 0.1 mg kg-1.

9.5 Benzo-a-pyren < 25 µg/kg

In addition, the PAH-thresholds for EBC premium quality (4 mg PAH16 kg-1), biochar for animal feed is subject to the specific reference limit for carcinogenic PAHs of 25 µg kg-1 benzo-a-pyrene.

9.6 Dioxine, furane, dioxin-like PCB (WHO-PCB) und non-dioxin-like PCB (DIN-PCB).

The EU feed regulations prescribe strict limits for polychlorinated dioxins, furans and PCBs, which are well below the limits of the soil protection ordinance. Therefore, (1) each batch of feed biochars must be analyzed for these substances, and (2) the accredited test method must have a lower detection limit. Consequently, special test methods and limit values for feed grade biochar apply here.

For PCDD / PCDF, a trigger value of 0.5 ng TE kg-1 at 88% DM and a limit of 0.75 ng TE kg-1 at 88% DM apply. For dl-PCB, a trigger value of 0.35 ng TE kg-1 at 88% DM applies. For PCDD / PCDF + dl-PCB the threshold is 1.25 ng TE kg-1 at 88% TS. For the sum 6 of DIN PCB, a limit value of 10 µg TE kg-1 at 88% DM applies.

9.7 Fluor < 150 mg kg-1 (88% TS)

Fluorine salts are usually volatile in pyrolysis conditions and will hardly occur in biochars in significant concentrations. However, according to the feed ordinance, the analysis is required by default.

9.8 Dry matter, crude ash, ash insoluble in hydrochloric acid

The specification of dry matter, crude ash content and HCl-insoluble ash are prescribed standard values of the EU feed regulations and must be stated on the product label. The content of the ashes must be determined by combustion at 550°C and given on a 88% dry matter basis.

9.9 Crude protein, crude fibre, crude fat

The indication of crude protein, crude fiber and crude fat contents are prescribed standard values of the EU feed regulations. Crude protein, crude fiber and crude fat are completely decomposed in the course of complete pyrolysis and are therefore no longer present in biochar. A biochar is considered to be completely pyrolyzed if the H / Corg ratio is <0.7. If the H / Corg ratio according to EBC premium quality is less than 0.7, the analysis of crude protein, crude fiber and crude fat is not required and set by definition as 0 g kg-1. The information is mandatory and must be stated on the product label.

14. Analytical Parameters for EBC-Feed (to be translated soon)

This section can be found in the original German at the EBC website:

European Biochar Certificate

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