About Filthy Feed

The use of poultry litter as cattle feed is dangerous because it creates a risk for Mad Cow Disease, bacterial and viral illness, antibiotic resistance, and exposure to toxic substances. This practice threatens both animal and human health. It commonly occurs in regions of the country where cattle and poultry operations co-exist. This report provides the first comprehensive review of this essentially unregulated agricultural practice. With so much at stake, the federal government no longer can afford to turn a blind eye to the dangers posed by filthy cattle feed.

Food Animal Concerns Trust (FACT) is a Chicago-based nonprofit organization whose mission is to improve the welfare of food producing animals. We seek to broaden opportunities for humane farmers; and address public health problems that come from the production of meat, milk and eggs. FACT was at the table in 1996 with scientists and regulatory officials when Mad Cow Disease in cattle was first linked to neurological disease in people. Since then, FACT has given testimony, participated in stakeholder meetings, submitted comments, and otherwise encouraged the U.S. Food and Drug Administration (FDA) to enact the strictest controls possible to prevent the spread of the disease.

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poultry litter

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food animal concerns trust

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This report is a project of Food Animal Concerns Trust; **Richard Wood**, Executive Director

FACT's Mission
Our mission is to improve the welfare of food producing animals. We seek to broaden opportunities for humane farmers, and address the public health problems that come from the production of meat, milk, and eggs.

FACT's Vision
Our vision is that all farms will one day be healthy and humane places for farm animals to live.

More information about Food Animal Concerns Trust is available on the FACT website at www.foodanimalconcerns.org.

The full text of this report is available online (in PDF format) at www.filthyfeed.org or may be obtained either by emailing info@foodanimalconcerns.org or calling (773) 525-4952.

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Executive Summary

Introduction

Food Animal Concerns Trust (FACT) is a Chicago-based nonprofit organization whose mission is to improve the welfare of food producing animals. We seek to broaden opportunities for humane farmers and address public health problems that come from the production of meat, milk and eggs.

FACT believes that healthy animals are essential for maintaining a safe food supply. FACT was at the table in 1996 when Mad Cow Disease in cattle was first linked to neurological disease in people. Since then, FACT has given testimony, participated in stakeholder meetings, submitted comments, and otherwise encouraged the U.S. Food and Drug Administration (FDA) to enact the strictest controls possible to prevent the spread of the disease. A ban on feeding poultry litter to cattle has long been an important concern for FACT. The FDA failed to include such a ban in its 2008 Final Rule on Substances Prohibited From Use in Animal Food or Feed (hereafter referred to as the Final Feed Rule).

Purpose

FACT, shocked by how little is publicly known about the feeding of poultry litter to cattle, undertook an extensive review of the scientific and policy literature surrounding the practice. Poultry litter consists primarily of manure, feathers, spilled feed, and bedding material that accumulate on the floors of the buildings in which turkeys and chickens are raised. In the United States, poultry legally can be fed ruminant meat and bone meal (MBM), rendered cattle material which may contain infectious prions that are responsible for serious neurological diseases. When this poultry litter is fed back to cattle, the cows are at risk of contracting Mad Cow Disease, otherwise known as Bovine Spongiform Encephalopathy (BSE). Consequently, humans who eat meat from infected cows are at risk for variant Creutzfeldt-Jakob disease (vCJD), a degenerative and often fatal neurological disease. Feeding poultry litter to cattle carries other serious health risks as well, including those related to (1) disease-causing bacteria and viruses; (2) drug residues; (3) antibiotic resistant bacteria; and (4) heavy metals and other toxic substances. This report argues that the FDA should reinstate its regulatory authority over poultry litter as feed and subsequently ban the practice.

Scope of the project

This report contains a scientific and policy review of the use of poultry litter as cattle feed. It lays out a brief history of how the practice emerged as the poultry industry in the United States expanded, and how the FDA delegated its regulatory authority to the state agricultural agencies. The report considers how the lack of regulation at the state level has placed animal and human health at risk by allowing this practice to continue. Particular aspects of contemporary litter composition and processing are discussed in depth to expose specific health hazards. The report also reviews the current processing guidelines available to producers, which largely contradict one another and provide minimal useful information. Furthermore, the approach used by the FDA to assess the risk associated with litter feeding is critiqued. The report emphasizes the need to strengthen policies that would protect against BSE and the numerous other health risks attributed to the practice.

Findings and Conclusions

The feeding of poultry litter to cattle is a contemporary agricultural practice that carries many animal and human health risks. In 1980, the FDA reversed an earlier ban on the practice and transferred the jurisdiction of litter-feeding regulation to individual state agricultural agencies because of the perceived local nature of the practice. Unlike other practices that have been adequately monitored at the state level, the feeding of poultry litter to cattle has been ignored by most states. It is unclear how much litter is being fed and if it is being processed properly. It appears that most states do not monitor the practice, which means that it would be extremely difficult to trace and rectify the related public health problems.

The threat of BSE to cattle and the associated risk of vCJD to humans are the most compelling reasons why the FDA should reconsider its 1980 decision to allow individual state agricultural agencies to monitor their own litter-feeding practices. However, since then the state agencies have only minimally regulated the practice, if at all. Considering the possibility that infectious prions could be transferred to cattle through consumption of spilled feed or poultry manure, the FDA should ban the practice of feeding poultry litter to cattle altogether. The FDA's Final Feed Rule still allows 10 percent of infected tissues from cattle to be fed to poultry, thus creating a possible route of BSE transmission to cattle.

Beyond the risk of BSE, the practice of feeding poultry litter to cattle carries other potential health risks. Drugs and drug residues, bacteria and viruses, and heavy metals are among some of the lurking public health problems in the litter. Unfortunately, cattle may be at increased risk from harmful metals found in poultry litter used as feed, but no federal or state agencies currently test for their presence. As for the drugs and drug residues found in poultry litter, they contribute to the development of antibiotic resistant bacteria on farms. While increased bacterial resistance in farm animals threatens animal health, more significantly it exacerbates the spread of antibiotic resistant bacteria from the farm into the community through contaminated food, waterways or soil, and farm workers. Antibiotic resistance is a

serious public health problem that increases the total number of infections as well as their severity, often leading to prolonged treatments, higher healthcare costs, and the possibility of patient deaths. Finally, disease-causing bacteria may persist in cattle feed and slowly make their way into the community as processing methods do not effectively eliminate them.

The practice of feeding poultry litter to cattle continues today without adequate surveillance or regulation. The FDA, as a government agency with a strong public health mandate, must protect human health before considering the economic interests of the agricultural industry. Cheap feed does not equal good feed. The evidence is clear: poultry litter as cattle feed carries the undeniable risk of BSE transmission. With so much at stake, the federal government no longer can afford to turn a blind eye to the dangers posed by filthy cattle feed.

Chapter 1
A Dangerous Practice

Is this What You Want Your Dinner To Be Eating?

The feeding of poultry litter to cattle is a dangerous agricultural practice that should be banned by the U.S. Food and Drug Administration (FDA) to protect animal and human health. Poultry litter consists primarily of manure, feathers, spilled feed and bedding material that accumulate on the floors of the buildings where chickens and turkeys are raised. It can contain disease-causing bacteria, antibiotics, heavy metals, toxic materials, feed ingredients normally prohibited for cattle such as meat and bone meal from dead cattle, and even foreign objects such as dead rodents, rocks, nails and glass. This material is collected and processed using techniques such as composting or deepstacking. It is then added to cattle feed because of its high protein and mineral content, and due to the higher costs associated with other manure disposal options.

The known dangers associated with this agricultural practice create an unacceptable risk to human and animal health. Documented risks include the spread of Mad Cow Disease,[i] the development of antibiotic resistant bacteria, and the potential for exposure to toxic substances. The risk to human and animal health is further compounded by the widespread absence of surveillance or regulation. In a period marked by increasing public demand for traceability in the food supply, the uncertainty as to the prevalence and regulatory status of litter-feeding seems all the more shocking. Currently, serious health threats could go undetected and unchecked.

Since 1980, the FDA has shirked its responsibility to address the human and animal health concerns related to the use of poultry litter as feed for cattle. In 2008, despite a growing public recognition that food safety is of paramount importance, the FDA failed to include poultry litter among the substances prohibited as cattle feed when strengthening rules to prevent the spread of Mad Cow Disease.[1] As the following review of the available scientific and regulatory literature demonstrates, the FDA has the authority to ban this practice and should promptly do so.

[i] Mad Cow Disease is the commonly used name for Bovine Spongiform Encephalopathy (BSE), a slowly progressive, degenerative, fatal disease affecting the central nervous system of adult cattle. http://www.fda.gov/AnimalVeterinary/GuidanceComplianceEnforcement/ComplianceEnforcement/BovineSpongiformEncephalopathy/default.htm.

Growth of the poultry industry

During the last 50 years there has been rapid growth[2] and consolidation[3] within the U.S. poultry industry, accompanied by commensurate growth in the amount of litter produced. It is estimated that each of the 70,000 broiler chicken houses[ii] in the United States generates approximately 180 tons of litter per year,[4] consisting of varying proportions of manure, feathers, spilled feed, and the bedding material on which the birds were raised (which may include wood shavings of various sources, rice hulls, sawdust, paper mill waste, peanut shells, coconut fiber, and other dry, absorbent materials). The composition of this highly heterogeneous product varies with climate, bird population density, feed and bedding material, and other aspects of broiler house management. Most litter is high in nitrogen and phosphorous and has traditionally been used as a fertilizer for crops, particularly forage crops. The rapid growth in poultry production in the mid-to-late 20th century especially in the southern and southeastern states, gave rise to a problem of litter disposal. Eutrophication of coastal and surface waters, due to excessive deposits of phosphorus-rich raw (unprocessed) poultry litter,[5] prompted interest in alternative-disposal strategies, including feeding poultry litter to cattle.

A brief regulatory history of poultry litter feeding

In a 1977 *Federal Register* notice,[6] the FDA proposed amending the Food, Drug, and Cosmetic Act (FDCA) to allow poultry litter to be used as feed for animals. Since 1967 the FDCA had disallowed litter use in cattle feed and had classified it as a feed adulterant based on its capacity for microbial contamination.[7] In 1980, following a three-year comment and review period, the FDA issued a final rule by which the jurisdiction of litter-feeding regulation was transferred to individual state agricultural agencies.[8] In this notice of revision, the FDA stated that poultry litter is safe from microbial contamination if properly processed, but did not give substantial recommendations to the states on how effective processing should be accomplished.

Based on the following provision in the notice's introduction, it is evident that the FDA was not assured of the general safety of the practice. The notice reads:

> *The data available to FDA…do not resolve all the questions of safety that are raised by the possible occurrence of residues of drugs and drug metabolites in recycled waste. Moreover, it has become clear that such questions might not be answerable in the foreseeable future even if extensive research efforts were devoted to this purpose.* Hence, the agency recognizes that it is necessary to weigh associated safety factors such as the levels likely to be fed, the consuming species and production classes of animals, the probability of practical withdrawal periods following feeding, and the overall extent of the practice of recycling animal wastes in this country in order to develop an assessment of the safety impact of such feeding practices (p. 86272; emphasis added).

[ii] This figure was calculated by dividing the number of young chickens slaughtered per year (8,898,486) by the number of birds per house (120,000). The later calculation assumes 20,000 birds per flock and 6 flocks per year in each house as described at http://pubs.caes.uga.edu/caespubs/pubcd/L419.htm. This estimate does not include the number of houses used for breeder flocks as there is not a reliable way to calculate this figure.

The FDA officially delegated the authority to regulate poultry litter as a feed ingredient to individual state agricultural agencies due to the "local character of animal waste use and because the States have the capacity to effectively regulate this use."[8] Unfortunately, the FDA took this step without first guaranteeing that the states would conduct a comprehensive safety assessment before allowing litter to be used as feed. There was no requirement that the states explicitly address any of the associated safety factors cited by the FDA. Several recent surveys of state agricultural agencies indicate that most states' policies are either unknown or nonexistent. Enforcement of those policies may be sporadic at best.

Countries that have banned poultry litter as cattle feed

Australia
Canada
European Commission Member States
New Zealand

A 1996 survey of state agricultural agencies determined that 31 of 32 responding agencies have documented policies regarding the use of animal waste in commercial feed. Of these policies, most were adapted from standards established in 1982 by the Association of American Feed Control Officials (AAFCO).[9] This survey yielded no information as to the surveillance or enforcement associated with these policies. AAFCO's model regulations call for licensing and periodic screenings (for *Salmonella* and *E. coli* bacteria, heavy metals, pesticides, drugs, parasitic larva or ova, and mycotoxins)[10] of animal wastes registered as commercial feedstuffs. These requirements seem spurious given the apparent rarity of its commercial registration.[9,11]

An informal survey conducted in 2007 by Food Animal Concerns Trust, a science-based public health and humane farming nonprofit organization, found that 21 of 32 responding state agencies reported that they did not monitor or maintain any data on the amount of poultry litter used as cattle feed. As one respondent said, "We do not have any information of the amount used. We only know that it is done." Two states supplied estimates of the amount used based on limited survey data.[12]

Adding to the problem, poultry litter is also not among the "byproduct feeds" whose

prices are monitored in the Feed Grains Database maintained by the Economic Research Service of the U.S. Department of Agriculture (USDA).[13] The private use or non-commercial exchange of poultry litter or other animal wastes as feed is common, according to anecdotal evidence and industry literature. A 2002 survey of approximately 15,800 broiler producers and 500 turkey producers indicated that 34% of litter was sold and 17% was informally traded.[14]

The FDA originally may have thought that delegating the regulation of poultry litter as cattle feed to the state agricultural agencies would minimize the health risks posed by the practice. Almost thirty years later, the majority of states do not have known policies on the regulation of litter as feed, and poultry litter is rarely registered as commercial feedstuffs despite being used as cattle feed. It is safe to conclude that the individual states have not lived up to their mandate from the FDA. Therefore, the FDA should reinstate its authority immediately to address the health risks associated with poultry litter feeding. While the feeding of litter may primarily occur locally or regionally, it has national implications. Cattle are often moved long distances across state lines for finishing or slaughter; beef products from these cows can then enter into national or even international commerce. Far from being of local concern only, this practice could affect the health of a much larger, national population and thus should be regulated by a federal agency.

Estimates of the Amount of Litter Fed to Cattle

Estimates range from the 1% figure offered by the U.S. Poultry and Egg Association (USPEA) in 2002[15] to notably higher assessments of 20-25% and 25% by researchers at the FDA and Virginia Polytechnic Institute, respectively.[16,17] The USPEA's figure almost certainly is an underestimate because it only includes litter fed directly by poultry producers to their own livestock and does not include information on the final use of the bulk of litter (51%), which is sold or traded.

When the FDA estimated the economic costs of a ban on feeding poultry litter as a response to BSE in 2005, the Agency assumed that between 1.1 and 2 million tons of litter would be fed to between 1.3 and 3.2 million cows.[39] The FDA did not state what percentage of the litter produced this would represent. However, if reports that 5.6 million tons of litter are produced annually are accurate,[17] this would mean that the cost estimates calculated by the FDA assumed that between 20% and 36% of litter is fed to cattle.

Regional variance in feeding practices is not well quantified, but is presumably limited by the geographical distribution of poultry production, as litter is considered prohibitively expensive to transport over long distances. A review of the literature and several inquiries to agricultural researchers yielded a wide array of estimates for major poultry and beef-producing states:

Alabama: In 2004, Auburn University bioengineers estimated that 5% of the litter generated in Alabama was fed to cattle.[18]

Arkansas: Per a 1997 survey published by Physicians Committee for Responsible Medicine, "18 percent of chicken farmers use their accumulated chicken litter for cattle feed."[19]

Florida: The Florida Department of Agriculture estimated in 2004 that approximately one million tons of poultry litter are produced in Florida each year. If it is assumed that only 35% of this material is suitable for use in animal feed, then 350,000 tons of poultry litter would be available annally as cattle feed or for other uses.[20]

Kentucky: In a qualitative survey of food safety perceptions among approximately 570 Kentucky beef producers published in 2001, 2.9% of respon dents reported feeding poultry litter; 51.7% of all producers surveyed considered it a high-risk practice.[21]

Tennessee: In a 2005 interview survey of off-farm poultry litter handlers, "twenty-five percent of handlers (i.e. 3 of those surveyed) sold litter as livestock feed."[22] A professor of agriculture at University of Tennessee was unable to estimate prevalence in his state, but stated that "Alabama and Georgia feed much more than Tennessee."[23]

Virginia: In 2004, the Virginia Farm Bureau estimated in comments to the FDA that approximately 10% of the poultry litter produced in Virginia, or 58,000 tons per year, is used as a cattle feed supplement.[24]

The variation and uncertainty in these estimates illustrates the absence of any significant monitoring at the state level and suggests that state governments are ill-equipped to respond to adverse health events associated with litter feeding.

Economic conditions and their effect on the use of litter as cattle feed

The uncertainty about current feeding levels is alarming considering the potential health risks associated with the practice. Looking ahead, the practice could become more common as new incentives to feed litter appear, such as the increasing price of other feeds, the value of litter as fertilizer, and the higher costs of other forms of litter disposal. The current regulatory structure is inadequate to monitor its prevalence, meaning that an increase in the practice could go unnoticed and essentially unregulated.

For cattle feeders, litter is considered an inexpensive protein and energy source, especially during the winter and drought periods. For example, a University of Nebraska study estimates that using litter as a feed supplement produces a saving of $0.04 per cow per day as compared to a feeding regiment that includes a

soybean supplement.[25] Texas A&M University researchers cite its per-ton cost at less than one tenth that of range cubes as a protein supplement.[26] Furthermore, an increase in biofuel production[27] could impact grain prices and fuel prices (which increase the cost of drying grain and forage crops). Under these circumstances, it is possible that the practice of feeding litter would become more common as cattle producers try to offset rising grain costs with alternative feeds. Poultry producers also find that selling litter for use as feed can be economically advantageous – in fact, litter sold for feed can yield prices 30% to 300% higher than litter sold as fertilizer.[22,28] It is not surprising that economic incentives drive the use of poultry litter as cattle feed. However, such dynamics underscore the need for the adequate surveillance and regulation of this practice.

Chapter 2
Mad Cow Disease: Policy, Science and History

A brief history of regulatory protections against the spread of BSE

Bovine Spongiform Encephalopathy (BSE), known commonly as Mad Cow Disease, is the most serious of the many serious health risks associated with feeding poultry litter to cattle. BSE is an important neurological disease in cattle that can also lead to variant Creutzfeldt-Jakob disease (vCJD), a fatal human neurological disease. BSE belongs to a group of diseases referred to as transmissible spongiform encephalopathies (TSEs), diseases that are believed to be spread through the misfolding and accumulation of infectious proteins, or prions, in nerve cells.[29] Neurological damage is caused by the accumulation of these misfolded proteins in brain tissue. The diseases are considered 'transmissible' because they can be spread from one sick animal or person to another.

BSE primarily spreads between cattle through the consumption of feed containing meat and bone meal (MBM) from infected cattle.[30] Due to the direct link between consumption of contaminated feed and disease development, efforts to control BSE focus on limiting cattle exposure to feed containing ruminant MBM.

In 1986, the first confirmed case of BSE in cattle was identified in Sussex, England. In 1996, research linked BSE to the human disease vCJD, which is thought to be contracted by humans through the consumption of meat from BSE-infected cattle.[31] In response, one year later the FDA prohibited the inclusion of ruminant MBM in cattle feed because of BSE's recognized risk to human health. As poultry are not known to be affected by BSE, the FDA did not prohibit the feeding of MBM to poultry. When the rule was proposed, several commentators recommended that the feeding of poultry litter to cattle be prohibited. They warned FDA of the risk of BSE infectivity due to either spilled feed or infectious prions passing through the avian digestive tract.[32] Spilled feed is food intended to be consumed directly by poultry that instead is dropped on the floor of the poultry house, becoming a component of the litter. It is estimated that the poultry industry consumes 43% of the ruminant MBM produced in the United States.[33] Given that 3% of the total feed in a broiler house is typically spilled,[34] a litter lot may contain up to 3.4 tons[iii] of spilled feed for each flock raised on it.

[iii] This calculation assumes that each of 20,000 birds per flock was fed 11.4 pounds of feed, found at http://www.epa.gov/oecaagct/ag101/poultrynutrition.html.

In response to the concerns raised during the public comment period, the FDA stated in its final rule notice that a prohibition on feeding poultry litter was unnecessary because there were (1) no studies on the infectivity of BSE found in poultry feces; (2) no epidemiological evidence from countries with BSE proving this was a possible route of transmission; and (3) a lack of epidemiological evidence from countries with BSE. Since that time BSE has been detected in the United States and studies have found that feces can contain infectious prions. In addition, the FDA's argument is spurious because litter feeding is prohibited in European countries, places where epidemiological evidence potentially could have been found.[35]

In 2003, BSE was detected in cattle born in Canada, including a cow that was shipped to Washington State and slaughtered there. It is assumed that BSE was originally introduced into North America by cattle imported from the United Kingdom in the 1980s. The disease's presence in North America led to new levels of concern among consumers and producers regarding the safety of beef and other animal-derived foods. U.S. export markets were closed as countries refused shipments of beef because of BSE concerns. The detection of North American BSE showed that import controls had failed to keep BSE from being introduced on this continent, prompting the FDA's Center for Veterinary Medicine to revisit cattle feeding regulations. In January 2004, the FDA announced that it would ban feeding poultry litter because of the BSE risk associated with this practice.[36] Later that year, the FDA began rulemaking and sought public comments on steps to improve the 1997 ruminant to ruminant feed ban. Again, the FDA received comments warning against the use of poultry litter as cattle feed.[37,38]

In 2005, the FDA published a proposed rule that called for a comprehensive ban on BSE-associated specified risk materials (SRMs) in animal feed.[39] Astonishingly, the proposed rule did *not* prohibit the feeding of poultry litter to cows, in stark contrast to the Agency's prior announcement that it would. The FDA justified its decision[iv] to allow poultry litter in cattle feed on the basis of an unpublished calculation by the North American Rendering Industry (NARI).[40] This calculation took into account the risk attributable to prions found in spilled feed, but ignored the potential passage of BSE infectivity through the avian digestive tract. Such shortsightedness on the part of the FDA has endangered public health by allowing a practice that contributes to BSE transmission to continue.

In 2008, the FDA published its Final Feed Rule, effective April 27, 2009[1] and subsequently delayed until October 26, 2009.[41] The final rule prohibits the use of certain high-risk materials from all animal feeds, but permits the indirect feeding of ruminant MBM to cattle in the form of poultry litter. According to an FDA publication:

[iv] Justification can be found on page 22725 of the 2008 final feed rule.

> …scientific data indicate that roughly 90 percent of BSE infectivity is contained in the brain and spinal cord of cattle, and only about 10 percent of BSE infectivity is present in such cattle parts as the distal ileum of the small intestine, the dorsal root and trigeminal ganglia, and the retina of the eye.[42]

The FDA acknowledges that the rule, if implemented perfectly, would still allow 10 percent of infected tissues from cattle into the food supply.[43]

In addition to permitting a certain amount of infectivity, there are also serious concerns about the ability of slaughterhouses and rendering plants to effectively implement the rule. Meat from infected cows may not be detected due to limited testing and inspection for BSE. In 2006, the USDA Inspector General issued a highly critical report of a related USDA program responsible for removing potentially infective tissues from human food.[44] The USDA Inspector General reported significant problems with the program's ability to determine cattle age, a prerequisite for removing high risk materials. The report also found that most plants did not have adequate plans in place to guarantee SRM removal. In February 2008, a California meat packing plant failed to properly follow steps to reduce the risk of BSE, which led to the recall of 143 million pounds of beef. The plant's inability to follow the guidelines went undetected by the USDA for over two years and resulted in the largest meat recall in U.S. history.[45] Plants that render animals *not* for human consumption have even fewer inspectors, making it more difficult for the FDA to ensure effective removal of risky material from animal feeds. Additionally, the FDA has provided no guidance to small meat processors regarding rule implementation. Meat renderers report difficulty in disposing of risky materials.[46] Due to the inevitable gaps in implementation and the final rule's failure to ban the use of all tissue known to carry BSE infectivity in animal feed, ruminant MBM fed to poultry will continue to be a potential source of BSE infectivity.

Meat and Bone Meal (MBM): What is It?

MBM consist of animal tissues and bones that have been cooked and ground up for inclusion in various products, including cattle feed. The consumption of ruminant MBM by cows has been the primary route of transmission for BSE. This practice is banned in the United States. However, ruminant MBM can be fed to chickens and turkeys.

A flawed approach to assessing the risk associated with litter feeding

It is likely that this poultry litter loophole will result in the feeding of large quantities of recycled ruminant MBM to cattle. In the Final Feed Rule, the FDA determined that the risk of the transmission of BSE to cattle through poultry litter was low based

on calculations provided by NARI. However, certain highly questionable assumptions were made by NARI that likely led to an underestimation of risk.

The following factors were not adequately addressed in the FDA's conclusion that feeding poultry litter to cattle presents an acceptable risk related to the spread of BSE:

1. The ability of prions to resist degradation by both the avian digestive tract and chemical processing methods. NARI assumed that the only source of ruminant protein in litter was from spilled feed.

2. The potential for infectious prions to occur in discrete packets in feed in stead of being uniformly distributed. NARI assumed that feed is perfectly mixed down to the microgram level at which infectivity occurs.

3. The possibility that soil particles could enhance transmission of BSE via mixing with litter. NARI did not consider the impact of soil on TSE transmissibility.

4. The potential for other strains of BSE or TSEs to be spread, amplified, and/or modified by this practice. Information on other BSE strains was unknown at the time of NARI's calculation.

Because these factors are not included in NARI's risk assessment, the results most likely underestimate the threat to human health posed by litter feeding.

Prion resistance to degradation

The NARI calculation accepted by the FDA considered spilled feed as the only source of potential infectivity in litter. It ignored the larger risk coming from proteins that pass through the avian digestive tract. No specific studies considering BSE infectivity have been carried out on this possible route of BSE transmission. However, prions are known to resist inactivation by processes such as ultraviolet irradiation, metal ion chelators, acidification, boiling, dry heat and chemicals such as formalin, alcohols, and beta-Propiolactone.[47] Because of their resistance to degradation, prions should not be expected to lose infectivity under the physical conditions of the avian digestive tract.

In an investigation of the potential for scavenger birds to transmit TSEs, the Scientific Steering Committee for the European Commission's Health and Consumer Protection Directorate-General expressed doubt that bird digestion could eliminate

prion infectivity. IThe Committee concluded that avian feces pose a risk for TSE transmission.[48] Previous research has demonstrated that fecally-shed prions can maintain their infectivity following ingestion by other species. Based on findings in mice fed the feces of scrapie-infected sheep, World Organization for Animal Health representatives stated that:

A more recent study found that the bovine digestive tract did not eliminate prion infectivity even when it degraded the proteins to the point that they were undetectable using standard immunochemical methods.[50] No studies have been carried out on the impact of the avian digestive tract on prion infectivity.

> Gut contents and fecal matter may...contain infectivity. It is concluded that digestive contents and fecal material from livestock currently being fed with meat and bone meal potentially contaminated with BSE should-not be used as a feed ingredient for animal feed.[49]

Even if the resistance of prion proteins to degradation is not considered, only 75 to 80 percent of the crude protein in ruminant MBM is normally digested in the avian digestive tract. The remainder of the protein is excreted by the bird, without being digested.[51] Clearly the FDA's assumption that the only potential source of infectivity is from spilled feed is incorrect. NARI's calculation assumed that litter contained only 1% of the protein in feed and consequently only 1% of potential infectivity. This assumption is clearly false given that 20% of ruminant protein in feed is indigestible and that infective prions are highly resistant to degradation. It is likely that at least 20% of infectivity would survive in litter and be transferred to the cattle consuming the litter.

Even if the targeted 90% reduction of infectivity in feed anticipated under the new feed rules is achieved, NARI's calculation will still significantly overestimate the quantity of feed needed to be consumed for infection to occur. Their calculation fails to consider that at least twenty times as much protein and associated infectivity passes through the avian gut compared to the amount that is spilled from feeders. This raises serious doubt over the determination that abnormally large quantities of litter would need to be eaten by a cow to receive an infectious dose.

Distribution of infectivity in feed

Complicating our understanding of BSE are issues regarding the quantity of an infectious agent needed to cause the disease and its distribution in feed. If the infectious agent in feed tends to occur in discrete clumps or "packets," more of it could

be ingested at one time, thus increasing the likelihood that an amount sufficient to cause disease would be consumed. On the other hand, if the infectious agent is distributed evenly throughout the feed, it is likely that a smaller amount would be consumed at any one point in time by any single animal. NARI's calculation assumes perfect mixing and dilution of any infectivity in the animal proteins both during rendering and within the poultry house during cleanout. In its own calculations

However, there is evidence that infectious material is not mixed perfectly during the rendering of feed as observed by the pattern of infection found in cattle herds. Typically, a low incidence of BSE occurs within a herd, meaning single animals rather than entire herds become infected with the disease. Perfect mixing does not seem to explain the observed pattern of disease transmission. If prion infectivity were evenly distributed in feed, entire herds would become sick rather than individual animals.

The BSE Inquiry conducted in the United Kingdom considered the "packet" theory of MBM distribution as an explanation for this pattern.[52] When the report was completed in 2000, the committee was unable to reach a conclusion on the packet theory for two reasons. First, the necessary packet size needed for infection seemed to be too large given the particle size of rendered product. Second, scientists incorrectly assumed that the infectious dose for BSE was fairly large. Since then, oral infectivity has been shown at the 1 milligram level for brain tissue,[53] one thousand times smaller than the one gram level accepted in 2000.[54] This new knowledge about prions strongly supports the packet theory of MBM distribution.

In conclusion, the FDA's determination that massive quantities of poultry litter would need to be eaten for BSE infection to occur is likely inaccurate. It not only fails to account for the passage of infectivity through the avian gut but also assumes that infectivity is evenly distributed in batches of MBM rendered for feed. It is much more likely that the infectious material is unequally distributed, an alarming phenomenon given the small dose needed to transmit BSE to cattle.

The impact of soil particles on prion infectivity

Recent research implicates soil particles as a possible reservoir of TSE infectivity. These findings raise additional concerns about how inorganic matter in feed resulting from contact with the soil during storage and processing, or from feed additives may impact infectivity. For example, Johnson et al. examine the disease penetrance and infectivity of prion isolates in four environments. They conclude that oral transmissibility may be to 680 times higher in prions bound to inorganic microparticles from soil than in unbound prions.[55] Because litter is typically processed and stored outdoors or in outbuildings, contact with soil particles is to be expected. Given

its relative popularity as a drought or winter ration, long-term stockpiling may be expected as well. Moreover, inorganic additives in feed, such as anti-caking agents used in poultry feed production, may also impact transmissibility. In 2002, 42,000 tons of bentonite clay were used in the production of animal feeds in the United States.[56]

As previously described, prions are well known for their high thermal resistance. Therefore, as long as poultry are fed ruminant MBM, prions may be present in litter via spilled feed or poultry manure.[57] At the point when prions come into contact with soil particles, and subsequently increase their transmissibility, no litter processing method in contemporary use can be expected to attain the temperatures required to eliminate them or even reduce their numbers.

Potential risk associated with new BSE strains

Recent research has shown that there are different strains of BSE. One of the strains identified in an infected U.S. cow is likely an inheritable strain.[58] The rate at which this inheritable BSE may occur in the U.S. cattle population is currently unknown. It may have been the origin of the worldwide BSE outbreak. Other research has shown that one of the new strains is more likely to infect humans than typical BSE.[59] The existence of different strains of BSE creates uncertainty in evaluating the risks related to livestock feeding. First, the presence of inheritable strains that occur independently of feeding practices creates the potential for a continual reintroduction of BSE into the U.S. feed chain as infected cattle are slaughtered. Second, certain new strains could be more infectious to humans or more transmissible between cattle, causing increased risk of human and cattle illness.

The health implications of new BSE strains should be accounted for in risk assessments and policy decisions. The existence of new strains of BSE creates great uncertainties in determining risks related to litter feeding as it is possible that strains will be identified that are both more infectious to humans and more transmissible between cattle. Litter feeding could amplify these strains. This scenario would pose a much greater threat to public health than risks assessments previously have calculated. If the FDA cannot adequately evaluate the risk presented by this feeding practice – due to the uncertainty surrounding prion diseases – the Agency should reinstate a ban of feeding poultry litter to cattle immediately.

Harvard BSE Risk Assessment

In addition to the NARI assessment described above, the risk of feeding poultry litter was also assessed by the Harvard Center for Risk Analysis along with the Tuskegee University Center for Computational Epidemiology. They used mathematical

modeling to assess the risk of BSE found in the United States.[60] The assessment was updated in 2005, and again in 2006, to include poultry litter feeding in response to public comments.[61] The base case scenario examining litter use assumes that only 1% of poultry litter is fed back to cattle. The 1% figure was chosen based on the U.S. Poultry & Egg Association's 2002 survey of poultry producers.[62] The 1% figure includes only the amount of litter fed by poultry producers directly to their own cattle and does not include the bulk of litter (51%) that is sold or traded. Because of this, the base case scenario more accurately represents the best possible outcome as it is the actual amount that producers stated that they themselves used. If any of the litter traded or sold is eventually fed to cattle, this figure would be an underestimate. Even given this presumably low-risk scenario, the assessment found that feeding poultry litter to cattle increased human exposure to infectivity by 73%, an unacceptable risk attributable to this practice.[v]

Sensitivity analysis carried out using an assumption that 5% of poultry litter was fed to cattle resulted in a more than doubling (200 to 420) of the number of new cases of cattle infected with BSE. The assessors did not provide results for amounts of litter fed above 5%. As there are no reliable data on the extent of the practice, it is possible that much more than 5% of litter is fed to cattle. In fact, under current law, all litter legally could be fed to cattle.

As described previously, the FDA assumed between 20 and 36 percent of litter would be fed to cows in its calculations to determine the potential costs associated with banning poultry litter as feed.[39] This is much higher than the levels of feeding considered in the Harvard Risk Assessment.

The Harvard model also fails to take into account infectivity at low dosages and does not consider the potential for infectivity to be clumped in packets in feed or the different risk profiles presented by various BSE strains. In light of these additional factors, the risks associated with feeding litter to cattle are likely greater than the Harvard model has predicted.

The United States' focus on banning the direct feeding of ruminant MBM to cattle ignores other risk factors and routes of transmissibility. By allowing cattle to continue to be exposed to ruminant MBM either through spilled feed or poultry manure, the FDA puts cattle and humans at risk for TSE infection.

[v] Human exposure was increased from 3800 infective doses to 6600 infective doses.

Chapter 3
Health Risks: Pathogenic Organisms and Inadequate Litter Processing

Since the 1960s, the scientific community has recognized that litter feeding has the ability to transmit pathogenic organisms. In 1968, Alexander identified numerous potentially pathogenic bacteria in litter intended for animal feed including *Clostridium* spp., *Salmonella enterica*, *Corynebacterium* spp., *Staphylococcus* spp., *Streptococcus* spp. and *Mycobacterium* spp.[63] Considering the composition of poultry litter, it is not surprising that it may contain disease-causing microorganisms. Subsequent research has consistently found poultry litter to contain a complex bacterial mix with many potential pathogens in addition to those identified by Alexander. These bacteria include *Listeria monocytogenes*, *Pasteurella multocida*,[64] *Actinobacillus* spp., *Bacillus* spp.,[65] *Pseudomonas* spp., *Campylobacter* spp., *Yersinia* spp., *Aeromonas hydrophilia*, *Escherichia coli*,[66] *Facklamia* spp., *Bordetella* spp. and *Enterococcus* spp.[17] In addition to containing bacteria, litter could act as a source for the transfer of viruses[65,67] and pathogenic fungi.[64]

Pathogen Reduction Methods

Deepstacking is an anaerobic fermentation process in which litter is piled and covered to spontaneously generate pathogen-killing heat. Both pile height and covering material recommendations vary. Guidelines from Missouri University state that "litter can be stored in this form for up to five years with little loss of quality."[72] According to multiple cattle experts cited by Kwak, deepstacking is the process in most common use due to its simplicity and economic feasibility.[96]

Ensiling is a multiple-stage (aerobic and anaerobic) fermentation process in which litter is combined with plant material, moisture, and sometimes a sugar source to induce pathogen destruction via acidification.[112]

Composting is an aerobic process which typically generates less heat than deepstacking. Elimination of pathogenicity by this method may therefore be more problematic.

Litter feeding has been directly linked to serious illness in cattle from botulism[68,103,102] as well as a *Salmonella* outbreak in cattle fed improperly composted litter.[69] While no studies have directly linked the feeding of poultry litter to disease in humans, contaminated feed in general has been implicated in outbreaks of human foodborne disease.[70,71]

Litter processing and its impact on pathogen reduction

The literature available on litter processing raises more questions than it answers regarding the safety of poultry litter as feed. Litter in poultry houses is often contaminated with potentially pathogenic bacteria. Studies have shown that composting and storage can reduce the risk. Alexander demonstrated that storage of poultry litter for one to two months reduced *Salmonella* to undetectable levels. Many subsequent studies have shown that storage and processing of litter can reduce levels of pathogenic bacteria in litter.[67,73,97]

However, the degree to which processing effectively kills pathogens is confounded by the accuracy of sampling methods used to measure pathogen levels and by the limited number of pathogens examined. Studies that sampled stored litter intended for cattle feed have often failed to detect cultured pathogens,[66,74] but it is unclear if this is because pathogens were not present or because of the sensitivity of methods used for detection.

Laboratory techniques may produce inaccurate results in pathogen-elimination trials. A recent report by Buhr et al. suggests that the sensitivity of the swab test method typically employed in these studies is limited. Newer and experimental techniques detect significantly higher rates of true positive *Salmonella* cultures.[75] The methods and materials used for isolating bacteria can cause significant variation in outcome, as has been demonstrated in experimental assays for *Enterococcus faecalis*[76] and for different species of *Salmonella*.[77,78] Moreover, the reliance on bacterial culture assays by most pathogen-elimination trials may have produced misleading results. This is due to the use of cultural methods with limited sensitivity[79,80] instead of the more sensitive polymerase chain reaction (PCR) testing.[81]

Additionally, using culture methods can be inaccurate because many of the bacteria most frequently implicated in foodborne human illness – including *Campylobacter* spp.,[82] *Salmonella* spp.,[83] *Listeria*,[84] and some *enterococci*[85] – are known to persist in a viable, non-culturable (VBNC) state when subject to stress. This behavior may be linked to greater virulence and infectivity of the pathogen. Among the factors understood to induce the VBNC state are temperature extremes, lack of water, and acidity. Acetic acid, a common component of chemical poultry litter treatments, has

been shown to induce the VBNC state in bacteria associated with pathogenic as well as commensal food bacteria.[86]

Most of this research has focused on *Salmonella*, and so it does not provide any information on the many other potential pathogens in food. While many studies reported a reduction in *Salmonella*, other studies found a variety of bacteria in samples of poultry litter intended for feed including *Escherichia coli*.[66,79,97] Martin and Jeffrey did not find *Escherichia coli* O157:H7 in litter after processing.[74] This is not surprising as this strain of pathogenic *E. coli* is rarely found in poultry. These studies did not sample for other strains of pathogenic *E. coli* which have been found in poultry and are considered potential zoonoses.[87,88] Martin et al. did identify *Staphlococcus xylosus* in poultry litter intended as cattle feed, but failed to recognize it as a potential pathogen.[89] *Staphylococcus xylosus* is a cause of mastitis in cattle[90] and is also a cause of infections in humans.[91] Such findings clearly indicate that pathogens may persist in poultry litter despite efforts to eliminate them through processing.

Litter build-up and its relationship to pathogen survival

The 1980 *Federal Register* notice effectively lifted the federal restriction on the feeding of litter. It cited a collection of public commentary and an extensive review of the scientific literature. As thorough and appropriate as this review might have been at the time, it could not have foreseen the findings of post-1980 research and the emergence of BSE. It also could not have predicted widespread changes in agricultural practices that have altered the fundamental properties of poultry litter, such as the trend toward litter build-up.

Although litter has always been a non-uniform substance, the recent trend toward "litter build-up" strategies has modified the biological and chemical nature of litter. Litter build-up involves less frequent complete clean-out of the poultry house, as well as more frequent "de-caking" (removal of water-saturated litter) and chemical treatments (paraformaldehyde, phosphoric acid, hydrochloric acid, sulfuric acid, elemental sulfur, sodium bisulfate,[92] and aluminum sulfate) between flocks.[93,94] The trend toward litter build-up is the result of producers' desire to save money on costly cleanout procedures. However, it affects the safety of poultry litter as feed because the reported increase of chemical treatments may diminish the effectiveness of methods used for pathogen removal.

One valuable characteristic of litter is that it is inherently rich in ammonia and thus has a high alkalinity or pH. Historically, this attribute has aided in pathogen reduction during litter processing and storage. Excessive ammonia, however, is also harmful to the birds' health and can become very concentrated in a confined poultry house environment. It is now common practice to misuse chemical treatments in an effort to control ammonia problems and to reduce costs.

The chemical and physical changes associated with built-up litter have also reduced the alkaline nature of litter and, in doing so, increased the health risk caused by the pathogens found in litter. Several peer-reviewed studies of the microbicidal effect of the deepstacking process[95,96,97] attribute its efficacy in part to the naturally alkaline, ammonia-rich nature of poultry litter, as expressed below:

> Some of the principal factors involved in the elimination of pathogenic bacteria from litter during the deep-stacking process include spontaneous heating and ammonia generated by the litter...Ammonia is toxic to microorganisms, and the conversion of uric acid in litter to ammonia is believed to have a significant killing effect on pathogens in deepstacked litter. Various aerobic bacteria indigenous to litter that are known to actively decompose organic matter during the deepstacking process can antagonistically suppress the growth of pathogenic microorganisms.[96]

As a result of litter build-up practices, the poultry litter currently available to prospective cattle feeders does not share the physical, chemical, and microbiological characteristics of the ammonia-rich, single-flock litter samples tested in earlier studies. For example, litter which has been used for four to six broiler cycles can be expected to contain higher concentrations of pharmaceutical residues, metals, disease-causing bacteria and other potentially harmful substances than litter from a single flock.

Chemical alteration of poultry litter can be expected to alter the bacterial elimination process, especially when cost-saving concerns – unchecked by regulation – prompt poultry house managers to apply ammonia-reducing chemical treatments in smaller quantities than manufacturers recommend. Poultry scientists at the University of Arkansas acknowledge the prevalence of this practice, warning:

> When this practice is used on older litter with high pH levels, lesser amounts of treatment may only be lowering the litter pH to ideal levels for bacterial growth. Another consideration is the possibility of creating litter pathogens somewhat tolerant to litter treatments by exposing the pathogens to sub lethal amounts of treatment.[98]

Therefore, the danger in this development is that producers apply just enough ammonia to reduce odors and make the environment tolerable for the birds, but in the process they create the ideal conditions for pathogen survival.

Many other factors complicate the efficacy of deepstacking to eliminate pathogens. The dynamic interaction between heat, moisture, oxygenation, and alkalinity in the microbicidal process is generally understood as important, but has not been precisely quantified. As the authors of one processing trial explain:

> Ammonia is naturally generated by indigenous microorganisms in moist chicken manure at appropriate temperature and can cause a significant reduction of non-spore forming pathogens in stacked manure. *However, it is practice in commercial poultry production to let the manure dry in order to reduce the detrimental effect of ammonia on the birds. Under these circumstances the destruction of pathogens becomes less predictable...*The more basic the pH of the litter material, the more heat the pile generated. A 5 deg. C difference was observed between piles with neutralto slightly acidic pH versus those with basicpH readings at any point in time. Based on this data, litter treatments that lower pH may also inhibit the heating process of stacked litter[99] (emphasis added).

In a study presented at the Western Poultry Disease Conference in 2001, a team from the University of California reported great variations in temperatures generated by deepstacking among litter samples under different conditions as well as different parts of a given single sample. They found that:

> ...minimal 'safe' temperatures, those necessary to kill microbial pathogens, are depth dependent. Therefore regulations stipulating how a stacked poultry litter pile should be monitored for safety would need to reflect this.[100]

The effective processing of poultry litter is complicated by irregular litter composition, changing poultry house management practices, and the poorly understood interrelationship between moisture, heat and other factors. None of these concerns is adequately addressed in the guidelines and fact sheets currently in circulation to poultry litter handlers, as discussed below. Without precise measurement protocols and without regulation, on-farm processing and storage methods may allow the propagation of virulent, antibiotic resistant bacteria that could be transmitted to humans through improperly cooked food. These bacteria are capable of causing serious foodborne illness. Incomplete pathogen elimination may also endanger cattle health, as was demonstrated in fatal botulism outbreaks in cattle fed poultry litter in Canada, Ireland, the United Kingdom, and Brazil.[68,101,102,103,104]

Processing and storage of litter: variability in guidelines

In the absence of a standardized regulatory structure, a disparate body of guidelines and fact sheets published by industry groups, universities, and cooperative extension services has served as the source of best management practices for the use oflitter as feed. A considerable number of these documents were developed in the mid-1990s (prior to the emergence of prion diseases in the United States). As such, they do not reflect recent research into litter microbiology nor the recent trends in poultry feeding and litter management (i.e. the prevalence of ammonia reduction treatments).[105,106,107] Most guidelines state explicitly that litter should be processed before feeding, but vary widely in their subsequent recommendations for processing methods. The confusing, unmethodical, and frequently contradictory nature of these guidelines contributes directly to a lack of accountability in protecting animal and human health.

In general, the available guidelines fail to communicate that poultry litter is a heterogeneous product whose quality and composition vary according to bedding material, feed, and flock management practices. At least two fact sheets advise their readers to select only "quality litter," but offer no criteria for measuring quality.[106,107] Private litter processors seeking this information are unlikely to find help in published research studies, many of which employ expensive technologies such as mechanical aeration. In at least one study of deepstacking efficacy, the method by which the litter sample had been decontaminated was proprietary information and thus not disclosed.[108]

This lack of information is problematic because human error can easily compromise the processing methods in most frequent use (i.e. deepstacking and ensiling), as well as those less common methods for which evidence is largely anecdotal (pelleting, dehydration, irradiation, introduction of anaerobic bacteria, and spraying with propionic or acetic acid).[109] Both aerobic and anaerobic digestion and composting are more commonly associated with litter used as fertilizer,[110] but no regulations exist to bar litter processed by these lesser-known methods from being fed to cattle. In the absence of stringent guidelines and vigilant monitorin g, we can not be assured of the quality or safety of the litter product that is being fed to cattle in the United States today.

Processing recommendations collected from fact sheets and guidelines

Temperature recommendations:

Temperatures of 160 degrees Fahrenheit are required to effectively eliminate *Escherichia coli* and some *Salmonella* species.[111] As discussed above, these temperatures would be inadequate to deactivate prions should they be present in litter via feed spillage or excretion. Most litter processing guidelines warn against excessive heat, as the nutritive value of litter is reduced attemperatures above 160 degrees

Fahrenheit, at which point the Maillard reaction renders some proteins indigestible.[72] Warned that excessive heat may produce more ash and cause more nitrogen loss than is considered desirable for nutritive quality,[96] on-farm litter handlers may have an incentive to process their materials at lower temperatures than would eliminate pathogens.

Mississippi State University and the University of Utah both recommend deepstacking to 130 degrees Fahrenheit for pathogen removal and do not stipulate pile size.[112,113] Missouri State University recommends 140 degrees for temperature, 6 to 8 feet of stack height, and is among the few institutions to offer a time recommendation (three weeks).[72] In 1991, Auburn University recommended 142-158 degrees and did not specify stack height.[114] In contrast, a more recent publication by the same university warns against temperatures above 140 degrees, and recommends limiting the litter's exposure to air in order to prevent higher temperatures.[115] This Auburn publication recommends 20 days at 130 degrees for pathogen removal. Clemson University does not offer a minimum recommended temperature for deepstacking, but warns against overheating litter piles by completely covering them.[106] Other agencies' recommendations for deepstacking pile storage structures include open-sided pole barns, three-sided commodity sheds, free-standing clamp silos covered with 6-mil polyethylene and weighted with discarded automobile tires, and bunker or trench silos. This variability demonstrates that there is not a uniform manner of safely processing poultry litter for use as feed. The disagreement on temperatures needed for pathogen elimination as well as the lack of specificity over the amount of time needed to process reveals just how poorly regulated this agricultural practice is.

Moisture recommendations:

The available literature on moisture recommendations is contradictory and confusing. Therefore, it is difficult to judge which guidelines are best for producers to use. Most likely, producers use the recommendations of the nearest university extension service. As far as can be ascertained from the literature, moisture level recommendations are important for two reasons. Moisture level impacts the quality of the litter as feed and also plays an important role in moderating the internal temperature of the litter. According to some of the guidelines available to poultry litter handlers, moisture level should be kept between 12% and 25% to ensure that the protein contained does not become denatured and to ensure an edible texture for the cattle.[112]

More importantly, from a health perspective, moisture levels are crucial to maintaining appropriate pathogen-eliminating temperatures. Moisture level plays a role in the level of infectious disease risk and also interferes with heat generation in deepstacking and fermentation activity in ensiling. For example, ensiled litter was implicated in the botulism outbreaks cited above. As the moisture content of a pile increases, the temperature generated in the deepstacking process decreases, posing an obstacle to pathogen elimination. A study undertaken by Louisiana State University concluded that on-farm litter processing was only safe within the narrow range of 31-35% moisture.[93] Cattle scientists at North Carolina State University considered 60-65% an appropriate moisture level for ensiling and 25% for deepstacking.[105] Missouri University recommends 20% moisture in its guidelines for deepstacking.[72] Mississippi State University recommends that, "for ease of processing and feeding, moisture in the broiler litter should be between 12 and 25 percent" when deepstacking litter.[112] As stated above, university extension services – the most obvious source of information for litter handlers – do not agree on the appropriate moisture level for processing poultry litter. Considering the implications both for the quality of feed for animals and for the infectious disease risk inherent in the litter, these conflicting guidelines illustrate the need for federal level regulation.

pH recommendations:

At least four guideline documents discuss the ensiling process and offer recommendations for materials and proportions. However, only the guidelines from Missouri State University specify a pH threshold by which to gauge successful fermentation, citing a pH level of 4.7 as sufficient to kill litter pathogens.[72] This may be inadequate given the reported capacity of some *Salmonella Typhimurium* to survive both a 2.6 and 4.0 pH growth medium.[116]

Foreign object screening and removal:

The contents and physical consistency of litter will vary with broiler house management and sanitation practices. Litter can contain potentially pathogenic items such as dead birds, dead rodents, and feces from pest animal. Litter also may contain dangerous items such as rocks, wire, nails, glass, and even larger objects such as tools.

North Carolina State University guidelines stated that litter "should be free of hardware, glass, and other foreign material," but offers no guidelines for screening.[117] Mississippi State University recommends screening with magnets for metal object removal.[112] Utah State University recommends "planning ahead with the poultry producer."[113] Other guidelines fail entirely to address the issue of foreign objects in feed, which is an alarming prospect for animal health.

These recommendations for processing poultry litter are variable and often conflicting. The FDA could not have had such an end result in mind when it delegated authority to regulate litter to the state agricultural agencies. The complete lack of uniformity in these guidelines suggests that there is very little oversight of the final product fed to cattle in the United States – a dangerous reality for both cows and humans.

Chapter 4
Health Risks: Drugs, Residues and the Development of Antibiotic Resistant Bacteria

The presence of veterinary drugs and their residues in meat and poultry presents health risks for human consumers. At the individual level, these substances may induce allergic or acute toxic reactions. They also may disrupt gastrointestinal flora as well as contribute to chronic low-level toxicity. Residues of veterinary ionophores may interact adversely with animal[118] and human medications.[119] Cattle can also suffer negative health effects due to the presence of drug residues in their feed.

At the population level, the use of antimicrobial agents in food animals can lead to the development of reservoirs of antibiotic resistant bacteria on farms. Antibiotic resistant bacteria can cause serious infections and health problems in animals.[120] It also exacerbates the spread of antibiotic resistant bacteria from the farm to humans through contaminated food, water, and infected farm workers.[121] Antibiotic resistance is a major public health concern, as resistant infections are harder to treat and increasingly lethal.[122]

Drugs and drug residues

Drug and drug residues in poultry litter pose a serious risk to human and cattle health. AAFCO's model feed regulation standards distinguish medicated from non-medicated feedstuffs, and accordingly recommend different levels of oversight. In the states that have adopted these model standards,[vi] poultry litter is not subject to the more stringent regulations imposed upon medicated feeds. Such a decision is misguided given the likely presence of pharmaceutical compounds from spilled poultry feed and within poultry manure itself.

Among the drugs routinely administered via feed to broiler chickens in the United States are the antibiotics bacitracin, tylosin, bambermycin, lincomycin, virginiamycin, and ionophores narasin and salinomycin.[123] In addition to these commonly used antibiotics there are many other veterinary drugs that are used in poultry production either for approved indications or extralabel purposes. There is no publicly available information on the quantity of drugs used in poultry production so it is impossible to accurately characterize the risks this use creates when litter is fed to cattle. It is estimated that, due to their water-soluble nature, 30-90% of veterinary antibiotics are poorly absorbed and excreted whole.[124] Modified antibiotic metabolites, also frequently excreted, are often bioactive and can be transformed into the parent

compound after excretion.[125,126] The FDA regularly maintains maximum residue levels (MRLs) for certain *cattle* drugs in beef tissue, but the risks associated with accumulated *poultry* drugs in beef tissue have not been assessed. Title 21 of the Code of Federal Regulations, in which animal drug MRLs are codified, maintains no MRLs for lincomycin, narasin, and salinomycin in cattle tissue.[127,128,129]

Independent of whether or not a drug is approved for use in cattle, the presence of antibiotics or antibiotic residues in poultry litter used as feed creates a health risk for cattle. Unexpected drug interactions can cause animal health problems. For example, certain kinds of ionophores can be toxic to cattle. If those ionophores are present in litter fed to cattle, they could combine with the ionophores administered directly to cattle and create an adverse reaction.[130] Ionophore toxicity in poultry litter used as feed has led to illness and death in cattle.[131,132]

The last peer-reviewed and published experimental analysis that specifically focused on veterinary drug residues found in the tissues of beef cattle fed broiler litter was published by Webb and Fontenot in 1975. The study found that litter contained four of the five antibiotics administered to chickens at levels comparable to those found in medicated feeds. It measured tissue concentrations of only one antibiotic, chlortetracycline.[133] The use of antimicrobials in poultry has changed since the mid-1970s when this study was completed. It did not look at the antimicrobials commonly used today such as bambermycin, lincomycin, virginiamycin, or ionophores.

The development of antibiotic resistant bacteria

Because of their ability to kill or inhibit the growth of susceptible bacteria, antibiotics are critical tools in human and veterinary medicine. At the same time, bacterial populations respond to the use of antibiotics by developing resistance – meaning that bacteria that survive exposure to antibiotics are the ones that multiply and pass on the ability to withstand antibiotic treatment. The development of resistance to antibiotics used in human medicine is a deepening public health crisis.[134] Overuse in human medicine contributes directly to resistant bacterial infections, but antibiotic use on livestock farms leads to increased resistance in bacteria in farm environments, farm animals, and in food.[135,136,137] Antibiotic resistance in foodborne pathogens is linked to increased numbers of infections[138] and increased severity of illness.[139,140,141] In particular, the large quantities of antibiotics that have been used in poultry production have been shown to negatively affect human health. Research on this topic demonstrates that poultry production is a source of antibiotic resistant bacteria.

The use of antibiotics in poultry has been shown to select for antibiotic resistance that can be transferred to humans.[142] The common use of antibiotics on poultry farms at doses lower than therapeutic levels is particularly problematic. This non-therapeutic use of antibiotics results in greater selection for resistance than the use of antibiotics at levels needed for disease treatment.[143,144,145,146,146,147] When transferred to humans, these antibiotic resistant bacteria can cause serious illness. For example, in 2005 the FDA withdrew approval for the use of fluoroquinolones in poultry because this use contributed to resistance in the foodborne pathogen *Campylobacter* spp.[148] Antibiotic use in hatcheries has also been linked to serious resistant *Salmonella* infections in humans.[149] In addition to causing resistant infections through the transmission of *Campylobacter* and *Salmonella*, poultry meat is a potential source for many other serious resistant pathogens including extra-intestinal pathogenic *Escherichia coli*[150,151,152] methicillin-resistant *Staphylococcus aureus* (MRSA),[153] and *Klebsiella*.[154]

Not surprisingly, poultry litter also contains antibiotic resistant bacteria. These bacteria are resistant to antibiotics that have a long history of use in animal agriculture as well as those more recently added to the drug arsenal for poultry production. Anywhere between 50 and 90% of *Enterococcus* isolates found in poultry litter are resistant to commonly used drugs.[155,156,157,158] Similarly high levels of resistance have been detected in *Salmonella*[159] and *Staphylococcus* isolates found in poultry litter and associated farms.[157] As would be expected, the majority of the bacterial isolates identified in poultry litter are resistant to multiple drugs.[66,160] Through the practice of feeding litter to cattle, resistant bacteria may make their way into cattle, farm environments, and to human populations.

In conclusion, the use of veterinary drugs in poultry production has serious health implications for cattle and humans. First, cattle are fed unknown quantities of antimicrobials due to their consumption of drugs contained in poultry litter. The existence of antimicrobials in litter could also lead to residue violations in meat – even if no one is testing for these particular MRLs. Second, the use of antibiotics in poultry and the persistence of secreted antibiotics in litter can lead to the development of antibiotic resistant bacteria. Antibiotic use on farm carries the risk of environmental contamination as resistant bacteria can be transferred between farms through the transportation of litter. Most significantly, antibiotic resistant bacteria cause serious infections in cattle and humans who consume infected beef products.

Chapter 5
Health Risks: Arsenic and Other Metals and Metalloids

Arsenicals are fed to chickens to grow larger birds more quickly using less feed. Some arsenicals are also approved for "improved pigmentation" and disease prevention. Currently, three arsenic-containing compounds are approved for use as feed additives in broiler chickens, the most common being roxarsone.[161]

Arsenic is classified by the U.S. Environmental Protection Agency (EPA) as a Class A known human carcinogen. It has been linked to elevated risk of liver, bladder, kidney, and lung cancers when ingested. Arsenic ingestion is also associated with mucous membrane damage, eye irritation, darkening and lesions of the skin, liver inflammation and damage, abnormal heart function, hearing loss, peripheral nervous system degeneration, and disruption of the immune system.[162]

Although an association between human exposure to poultry products and arsenic toxicity has been acknowledged for some time, the role of poultry litter in toxicity was first proven in 2007. It has been found that *Clostridium* spp. bacteria in poultry manure are responsible for the conversion of roxarsone into inorganic arsenic, which is toxic. Roxarsone is 3-nitro-4-Hydroxybenzene Arsonic Acid, an additive fed to 70 percent of the nine billion broiler chickens produced annually in the United States.[163] This dangerous conversion can begin within 10 days of excretion, but continues throughout the post-cleanout life of stored litter. The mechanism for conversion was elaborated recently by Stolz et al., who write:

> The organic-rich manure and anaerobic conditions typically associated with composting provide the conditions necessary for the native microbial populations to transform the roxarsone in the litter releasing the more toxic inorganic arsenic.[164]

Researchers estimate that up to 75 percent of the more than two million pounds of roxarsone fed to chickens annually will pass unchanged into their waste.[161] The consequences for cattle of inorganic arsenic conversion in their feedstuffs are unknown. Risk assessments for arsenic toxicity in cattle that have been fed poultry litter have not been conducted, adding to the list of overlooked problems associated with litter feeding. Even more troubling, the USDA does not routinely screen cattle meat for arsenicals as they are not approved for use in cattle.[165] Bioaccumulation of arsenic in cattle is likely, but the lack of surveillance by the USDA means the extent of the problem is not known.

Arsenicals pose a double threat because they enhance the selection of antibiotic resistant traits. The reservoir of bacteria found in poultry litter has been shown to contain large numbers of mobile genetic elements, or 'integrons,' that contribute to the spread and persistence of resistance genes.[166,167] Genetic linkages between antibiotic resistance and heavy metals could also contribute to the persistence of resistance genes in litter from chickens treated with arsenicals.[168] Genes encoded for antibiotic resistance are often grouped on integrons that also contain heavy metal genes. Bacteria with these integrons can survive exposure to any of the antibiotics or heavy metals to which they are resistant. Therefore, feeding heavy metals such as arsenicals to chickens also contributes to antibiotic resistance. As previously discussed, antibiotic resistant bacteria threaten animal and human health.

Other research has confirmed that broiler litter contains metals and metalloids. In addition to arsenic, Kpomblekou et al. found wide variations in the concentrations of other trace and nontrace metals in broiler litter from different facilities in Alabama. They attributed the variation to differences in broiler diet and house maintenance and sanitation practices.[169] Bolan et al. report potentially biotoxic levels of arsenic, copper, and zinc in poultry litter produced in South Carolina.[170] Cattle may be at increased risk from harmful metals and metalloids found in poultry litter used as feed.[vii] Risk assessments concerning arsenic and other metals present in poultry litter used as cattle feed should have been conducted *before* allowing the practice, a serious oversight by the FDA.

There is mounting evidence to suggest that the practice of poultry litter feeding has broad implications for human and animal health, beyond the threat posed by BSE. The toxic and disease-causing agents in litter tend to concentrate because of the recent changes in litter management. As discussed previously, before litter is fed to cattle, it is processed to reduce pathogen load and other harmful materials. However, the hodge-podge recommendations for processing litter are at best unclear and at worst ineffective at removing substances that could directly cause health problems for cattle – and ultimately humans who consume these animals. Moreover, because of the ubiquitous nature of antibiotic drug use in animal production, farms serve as major reservoirs of antibiotic resistant bacteria. When poultry litter is not properly processed to eliminate pathogens, humans are more likely to contract antibiotic resistant infections. Because litter processing methods are unreliable, there is no guarantee that human health is protected from these dangerous pathogens.

[vii] Copper toxicity can cause liver failure in cattle http://www.thedairysite.com/diseaseinfo/208/copper-poisoning-in-cattle and zinc toxicity can lead to decreased appetite in steers http://jas.fass.org/cgi/content/abstract/25/2/419.

Chapter 6
The Need for Federal Regulation

The feeding of poultry litter to cattle is an agricultural practice that endangers animal and human health. In 1980, the FDA reversed its previous ban on the practice and transferred the jurisdiction of litter-feeding regulation to individual state agricultural agencies. Unlike other practices that can be adequately monitored at the state level, the feeding of poultry litter to cattle has been ignored by most states. It is unclear how much is being fed and if it is being properly processed. It seems that most states do not monitor the practice, which means that it would be extremely difficult to trace and rectify related public health threats.

The single most compelling reason why the FDA should reconsider its 1980 decision is the threat to cattle and human health from TSEs. Since 1980, the state agricultural agencies have shown little interest or expertise in regulating the practice. Considering the possibility that infectious BSE prions could be transferred to cattle through spilled feed or poultry manure, the FDA should ban the practice of feeding poultry litter to cattle altogether. The FDA's 2008 Final Feed Rule does not eliminate 100 percent of BSE infectivity from MBM; therefore, the feeding of this material to poultry presents a serious risk when their feces are fed back to cattle. The emphasis on banning the *direct* feeding of ruminant MBM to cattle ignores the other risk factors and routes of transmissibility – to the detriment of animal and human health.

Beyond the risk of BSE, the practice of feeding litter carries other potential health risks. Arsenic, drugs and drug residues, and pathogens are among some of the lurking public health problems in the litter. Unfortunately, cattle may be at increased risk from harmful metals and metalloids found in poultry litter used as feed, but no federal or state agencies currently test for their presence. As for the presence of drugs and drug residues in poultry litter, they contribute to the development of antibiotic resistant bacteria on farms. Not only does increasing resistance threaten animal health, but it also exacerbates the spread of antibiotic resistant bacteria from the farm into the community through exposure to contaminated food, waterways, soil, and farm workers. Antibiotic resistance is a serious public health problem that increases the number of infections as well as their severity, often leading to prolonged treatments, higher healthcare costs, and the possibility of patient deaths.

One of the most important reasons why poultry litter is processed is to eliminate pathogens from the product. As the survey of extension services in the United States has shown, there is little uniformity in the recommendations given to those processing poultry litter. The confusing, unmethodical, and frequently contradictory nature of these guidelines demonstrates the need for a federal regulatory framework to deal with poultry litter as cattle feed. Even with federal oversight and regulation of the practice, feeding poultry litter to cattle would still carry the risk of BSE transmission to cattle and variant Creutzfeldt-Jakob disease transmission to humans.

The practice of feeding poultry litter to cattle continues today without adequate surveillance or regulation. The FDA, as a government agency with a strong public health mandate, must protect human health before considering the economic interests of the agricultural industry. Cheap feed does not equal good feed. The evidence is clear: poultry litter as cattle feed carries the undeniable risk of BSE transmission. With so much at stake, the federal government no longer can afford to blatantly ignore the dangers posed by filthy cattle feed.

Definitions

Antibiotic/antimicrobial: A substance that kills or inhibits the growth of microbes such as bacteria, fungi, or viruses. In modern usage, an antibiotic is a chemotherapeutic agent with activity against microorganisms such as bacteria, fungi or protozoa.

Association of American Feed Control Officials (AAFCO): An organization that provides a mechanism for developing and implementing uniform and equitable laws, regulations, standards and enforcement policies for regulating the manufacture, distribution and sale of animal feeds; resulting in safe, effective, and useful feeds.

Bovine Spongiform Encephalopathy (BSE): Also referred to as Mad Cow Disease, it is a slowly progressive, degenerative, fatal disease affecting the central nervous system of adult cattle.

Commensal: A form of symbiosis in which one organism derives a benefit while the other is unaffected (often refers to bacteria present in the digestive tract).

Eutrophication: An increase in compounds containing nitrogen or phosphorus in an aquatic or terrestrial ecosystem. It is often used to describe the excessive plant growth and decay attributable to the increase in these nutrients. It can lead to a lack of oxygen and severe reductions in water quality, fish, and other animal populations.

Extralabel use: The use of a drug product in a manner that is not consistent with what is indicated on the label, package insert, or product monograph of any drug product.

Isolates: To separate a pure strain of bacteria etc. from a mixed culture. The product, also called an isolate, is the strain of bacteria.

Meat and bone meal (MBM): A product of the rendering industry. It is typically about 50% protein, 35% ash, 8-12% fat, and 4-7% moisture. It is primarily used in the formulation of animal feed to improve the amino acid profile of the feed. Implicated in the spread of BSE.

Microbicidal: Harmful to microorganisms.

MRLs: Maximum Residue Levels, set by regulatory agencies to protect consumers against unacceptable levels of residues in food.

Mycotoxin: Any substance produced by a mold or fungus that is injurious to vertebrates upon ingestion, inhalation or skin contact.

Pathogen: An infectious agent that causes disease or illness to its host. Could be viral, bacterial, or fungal.

Polymerase chain reaction (PCR): A technique widely used in molecular biology for the detection and diagnosis of infectious diseases.

Penetrance: A term used in genetics describing the proportion of individual carying a particular variation of a gene (an allele or genotype) that also express a particular trait (the phenotype). More specifically, the likelihood a given gene will result in disease.

Prion: An infectious agent that, according to current scientific consensus, is comprised entirely of a propagated, misfolded protein. Implicated in the spread of TSEs, including Mad Cow Disease.

Rendering industry: Rendering is a process that converts waste animal tissue into stable, value-added materials. Rendering can refer to any processing of animal by-products into more useful materials, or more narrowly to the rendering of whole animal fatty tissue into purified fats like lard or tallow. Rendering can be carried out on an industrial, farm, or kitchen scale. The industry is represented by the National Renderers Association (NRA).

Risk assessment: The determination of quantitative or qualitative value of risk related to a concrete situation and a recognized threat (also called hazard).

Ruminant: A mammal that digests plant-based food by initially softening it within the animal's first stomach, known as the rumen, then regurgitating the semi-digested mass, now known as cud, and chewing it again. Ruminating mammals include cattle, goats, sheep, giraffes, American Bison, and others.

Specified Risk Material (SRMs): The general term designated for tissues of ruminant animals that transmit BSE and other TSE prions. These can include brains, eyes, spinal cord, and other organs.

Spilled feed: Food intended to be consumed directly by poultry but instead is dropped on the floor of the broiler house, becoming a component of the poultry litter.

Transmissible Spongiform Encephalopathies (TSEs): Diseases that are believed

to be spread through the misfolding and accumulation of infectious proteins, or prions, in nerve cells.

U.S. Food and Drug Administration (FDA): An agency of the United States Department of Health and Human Services (HHS) responsible for protecting the public health by assuring the safety, efficacy, and security of human and veterinary drugs, biological products, medical devices, our nation's food supply, cosmetics, and products that emit radiation.

U.S. Poultry & Egg Association (USPEA): Represents producers and processors of broilers, turkeys, eggs and breeding stock, as well as allied companies.

Variant Creutzfeldt-Jakob disease (vCJD): A fatal human neurological disease.

Viable, non-culturable (VBNC) state: Bacteria in the VBNC state fail to grow on the routine bacteriological media on which they would normally grow and develop into colonies, but are alive and capable of renewed metabolic activity. Cells in the VBNC state typically demonstrate very low levels of metabolic activity, but on resuscitation are again culturable.

Zoonosis: Any infectious disease that is able to be transmitted from other animals, both wild and domestic, to humans or from humans to animals.

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