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Ruminant Meat Meal May Lower Feed Costs

Parts I and II

The poultry industry has relied heavily on the use of animal byproducts. It is important for both the poultry and rendering industries to be reminded of the benefits that animal protein meals provide for the formulation of poultry rations. The attached reprint article from *Feedstuffs* provides reference data and formulation principles developed by Dr. Jeffre Firman, Professor and Researcher, University of Missouri. This past year, in which plant protein ingredients were priced higher than normal, created an increased usage of animal byproducts by the poultry industry. Though economics were responsible in part for the increase it was an opportunity for renewed interest in the use of animal byproducts to improve performance. Both broiler and turkey diets included more meat and meal in 2004 than in several past preceding years. In monitoring several commercial broiler and turkey diets MBM was utilized in well over 90% when offered in best-cost formulation models.

There may be a hype for all vegetable based diets. All vegan diets have been fed with marginal success. Most economic comparisons report an expected increase in formula costs of from $6 to $12 per ton and a resultant decrease in feed utilization for the all vegan rations. A frequent associative observation has also been an increase in water intake resulting in a wet litter condition that precipitates footpad lesions and other feet and leg problems. The increase in total ration oligosaccharide content as well as other toxins has been incriminated. Additionally pellet quality compromises and a reduction in feed production efficiencies have been noted. Thus the removal of animal byproducts from poultry diets not only raises the need for further research to solve those concerns but an overall assessment of the affected economics in maintaining poultry products' competitive advantage in the animal food marketplace. An opportunity exists to aggressively promote the documented benefits for the inclusion of animal byproduct ingredients in poultry diets.

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Ruminant meat meal may lower feed costs: Part 1

Animal byproducts as a group represent viable feed ingredients at prices that have traditionally been considered normal. When prices such as those found at the time of this writing for ruminant meat and bone meal occur, they can be a source of considerable cost savings for the poultry industry.

By JEFFRE FIRMAN, DAVID ROBBINS and GARY PEARL

There has been a long history worldwide of animal protein use in the poultry industry. Essentially, all sources of proteins have been and continue to be used in significant quantities in the U.S., with the primary issue being relative values compared to other protein sources such as soybean meal. Products currently being utilized include meat meals from ruminant, swine and poultry origin as well as the blood and fat products from each of these and feather meal.

Additionally, there is now some limited production of whole hen meal used as a disposal method for spent laying hens. Each of these products has been used successfully at various levels in rations for poultry of all types with the higher levels going into broilers and turkeys due to their higher relative protein needs compared with layers.

These products of animal origin provide nutrients needed by poultry at reasonable prices relative to competing products. In fact, prices tend to fluctu-

■ *Dr. Jeffre D. Firman, a professor of nutrition, and David Robbins are with the University of Missouri, Columbia. Dr. Gary G. Pearl is with the Fats & Proteins Research Foundation Inc. Part 2 of this article, which contains the list of references, will appear in the Nov. 1 issue of* Feedstuffs.

TABLES

1. Digestibility coefficients of selected amino acids in meat and bone meal as reported in literature since 1984

Amino acid	1984[1]	1989[2]	1990[3]	1995[4]	1997[5]	2000[6]
Lysine, %	65	70	78	92	71	87.5-92
Threonine, %	62	64	72	89	—	80.2-88.9
Tryptophan, %	—	54	65	—	70	86.4
Methionine, %	82	—	86	91	—	87.4-92
Cystine, %	—	—	—	71	—	76.4

[1]Jorgensen et al. (1984) — determined at the ileum of pigs.
[2]Knabe et al. (1989) — determined at the ileum of pigs.
[3]Batterham et al. (1990) — determined at the ileum of pigs.
[4]Parsons (1995) — high-quality meat and bone meal in poultry using the precision fed cockerel balance assay.
[5]Bellaver et al. (1997) — determined at the ileum of pigs.
[6]FPRF reports (2000) — upper range values for meat and bone meal as determined via ileal, intestinal and cockeral assays (Cromwell, Parsons, Klopfenstein projects).

2. Comparison of two formulations based on total amino acid content and the effect on digestible amino acid values

	Corn-soybean diet		Byproduct addition diet	
	Total basis, %	Digestible basis, %	Total basis, %	Digestible basis, %
Lysine	1.72	1.52	1.72	1.45
Methionine	0.55	0.52	0.55	0.44
Threonine	1.05	0.86	1.05	0.84

3. Incidence of salmonella in feed ingredients

		Country				
Ingredient	Item	Netherlands[1]	Germany[2]	U.S.[3]	Canada[4]	U.K.[5]
Animal proteins	Samples	2,026	17	101	NR	120
	% positive	6	6	56	20	3
Vegetable proteins	Samples	1,298	196	50	NR	2,002
	% positive	3	26	36	18	7
Grains	Samples	—	37	—	NR	1,026
	% positive	—	3	—	5	1
Fish meal	Samples	—	—	—	NR	1,316
	% positive	—	—	—	22	22

[1]Beumer and Van der Poel (1997).
[2]Sreenivas (1998).
[3]McChesney et al. (1995).
[4]Canadian Food Inspection Agency (1999).
[5]Brooks (1989).
NR = Not reported.

4. Efficacy of the U.S. rendering system in the destruction of pathogenic bacteria[1]

Pathogen	Raw tissue[2]	Post process[2]
Clostridium perfringens	71.4	0
Listeria species	76.2	0
Listeria monocytogenes	8.3	0
Campylobacter species	29.8	0
Campylobacter jejuni	20.0	0
Salmonella species	84.5	0

[1]Troutt et al. 2001. Samples from 17 different rendering facilities taken during the winter and summer.
[2]Percent of the number of samples found to be positive for pathogen out of the total samples collected.

ate based on prices of competing products. There has also been some interest in replacement of a portion of the soybean meal in poultry rations with animal products to improve performance.

The oligosaccharide portion of soybean meal has been shown to produce some detrimental effects to poultry. This is thought to be due to a substance in the undigested portion of the product that irritates the footpad.

The addition of animal protein sources may improve performance parameters significantly over standard diets. While these results may be due to high levels of limiting amino acids, they may also be explained by the reduction of poorly digested carbohydrates in the soybean meal.

Previous work in Firman's laboratory has suggested that up to one-half of the protein source can be provided with mixed byproducts if one formulates correctly. While each product has different nutrient contents and potential values, most are excellent sources of high-quality protein, highly available phosphorus and other minerals.

With the recent concern of bovine spongiform encephalopathy (BSE) in the U.S., there have been some questions about use and safety of ruminant-derived product.

While the safety of the product and its use in poultry rations is of concern, let's first address the use of ruminant-derived meat and bone meal in poultry diets as well as the use of other byproduct feeds. The goal is to provide the information needed to utilize these products in ration formulation, methodology for their use and limitations on their use as well as show something on the economics of their use.

Ultimately, with this information in hand, proper decisions about the use of these products can be made and money saved.

Available products

Ruminant meat meals are products produced from the rendering industry consisting of the non-edible portion of cattle processing. These products may vary somewhat, primarily based on the relative proportion of bone in the product. These are products heavily utilized in the U.S. poultry industry not only from the standpoint as a protein source but also as calcium, phosphorus and energy sources.

Inclusion levels are primarily limited by the potential for excess phosphorus, and of course, computer formulations will only allow for inclusion when justified by price, but 10% of the ration is commonly fed. Because of some of the issues surrounding ruminant-derived product, this discussion will focus somewhat on this area.

Poultry byproduct meal is the byproduct of the poultry processing industry and may consist of the offal and other inedible parts of the chicken. The main cause for differentiation of the products is based on the processing source. This may include portions of the chicken — such as the deboned carcass — in a further processing plant, while one that sells primarily whole birds may not have this portion of the bird and thus will have different levels of ash content.

This product has become more expensive in some cases as the high quality has led to its use by the pet food industry in the U.S.

The fat content of the product consists, of course, of the fat from birds, which is less saturated and, thus, may contribute to less saturation in the meat birds fed the product. Again, inclusion of the product is primarily limited by ash content but is most commonly around 10%.

Blood meal is a product based on a drying method from the blood processed in chicken, pork or beef plants. The more sophisticated the drying method, in general, the better the product produced. Thus, spray-drying is generally considered superior to vat-drying. A significant portion of blood meal is used for production of plasma proteins, although porcine blood is probably most heavily used for this.

Blood meal is generally not used in high concentration in poultry diets due to its amino acid balance. Constraints would be at 1-2% of the total ration.

Feather meal is the ground and hydrolyzed feathers from chicken and turkey processing. Generally, feather meal is considered to be low in digestibility with a poor amino acid balance and is thus not heavily used in the poultry industry. It is generally economically priced and will normally be used at a maximum of 1-3% of the ration. Higher levels can be fed when careful formulations are used, but this is rarely cost effective.

Blends are available commercially as well as custom blended to customer specifications, which generally increases costs and may not be a cost-effective alternative. Blends were more heavily utilized in the past. Some products were designed specifically as a replacement for fish meal. The value of blends has gone down as computer formulation has become more widely available and as formulation of diets on a digestible amino acid basis has become more widely accepted. The use of computers has allowed for a custom blend to be made for each diet based on the available ingredients and their cost-effective use.

Various animal fats and animal/vegetable blends can be used by the poultry industry depending on cost and availability, which includes tallow, choice white grease, poultry fat, yellow grease and blends of these. Fat inclusion is generally a price issue based on calorie cost. In general, fat can be fed at high levels with performance enhancement but is limited by cost and the physical ability of the feed mill to mix fat into the diets.

Literature review

There has been considerable work done with meat and bone meal, particularly in the area of protein and amino acids. Firman (1992) found that the amino acid digestibility of meat meal does not differ in turkeys of different age or sex and is similar to the rooster model commonly used.

Lysine and methionine are highly available for metabolism, but a significant amount of the cystine is not bioavailable (Wang and Parsons, 1998a). This is of importance because tryptophan and total sulfur amino acids are most limiting in meat and bone meal, followed by threonine, isoleucine, phenylalanine plus tyrosine, lysine, valine and histidine (Wang et al., 1997).

Several reports have found that the protein quality of meat and bone meal varies greatly. Parsons et al. (1997) found that the ash content is correlated to the protein quality. It is thought to be caused by the ratio of protein to ash in a ration. As ash increases, protein decreases. The amino acid digestibility is probably not actually decreased but diluted (Shirley and Parsons, 2001).

The method of determining digestibility can also have an effect, often yielding differing results (Johns et al., 1987). Fat additions to rations have also proved to be a factor as increased digestibility has been shown in the presence of high levels of fat. Increasing the fat component of a diet can slow gut motility, leaving more time for absorption. The micelles themselves may also help transport amino acids to the gut wall (Firman and Remus, 1994).

Digestibility can also be affected by

the presence of other ingredients, like soybean meal (Angkanaporn et al., 1996). It has been shown that formulating rations based on digestible or bioavailable amino acid levels provides better results than on a total amino acid basis (Wang and Parsons, 1998b).

One of the most important factors determining the nutritional quality of meat and bone meal is the processing procedure. With recent concerns over BSE, feeding ruminant-derived meat and bone meal to ruminants is banned in the U.S., and the European Union has banned the feeding of all products of animal origin to livestock. This leaves the poultry, swine, aquaculture and companion animal industries as the major consumers of meat and bone meal.

When a meal is rendered, the time, pressure and temperature of rendering may vary. The EU has mandated that animal byproduct meals be processed at 133°C and 30 lb./sq. in. for 20 minutes to increase safety. Unfortunately, this rendering process does not always inactivate the prion thought to be responsible for BSE.

Therefore, studies have been done to determine the nutritional effects of differing pressures, times and temperatures. While increasing pressure may reduce the possibility of BSE infection, it also decreases the availability of nutrients for the bird (Shirley and Parsons, 2000). Temperature also has proven to affect the availability of nutrients. Temperature has the same inverse relationship to nutrient availability as seen with pressure (Johnson et al., 1998), as does the processing time (Karakas et al., 2001).

Improvement in processing technology has recently resulted in improved nutrient availability, as demonstrated in Table 1. However, variation in quality is still an issue for the industry (Elkin, 2002).

Several other studies have looked at the ideal amount of meat and bone meal to be added to a ration. The level of inclusion of meat and bone meal to usual rations has been debated because of variations in metabolizable energy (ME), protein quality and available phosphorus. It is often included at 5% or less of the ration. However, Sell (1996) found that meat and bone meal could be added successfully to diets at up to 10% for turkeys.

As given in the name, bone is a component of meat and bone meal. This provides an excellent source of calcium and phosphorus. Drewyor and Waldroup (2000) noted that inclusion of meat and bone meal must be monitored to ensure that phosphorus levels are not so high that environmental issues arise. Others have found that the phosphorus in meat and bone meal is highly available to poults (Sell and Jeffrey, 1996).

Fortunately, prediction equations for phosphorus content have been developed similarly to those used to predict the ME value of a feedstuff. This rapid determination will aid in the formulation of rations utilizing meat and bone meal (Mendez and Dale, 1998).

Of primary concern is the ME content of meat and bone meal. As mentioned previously, the variability of the feedstuff makes it difficult to precisely determine a standard value. Waring (1969) found ME of 1,988 kcal/kg, lower than many estimates. The National Research Council (NRC, 1994) uses a value of 2,150 kcal/kg. However, early papers tended to underestimate ME of meat and bone meal, with it probably being between 2,300 and 2,500 kcal/kg (Martosiswoyo and Jensen, 1988; Dolz and de Blas 1992).

Species tissue origin may also have an effect. Dale (1997) found ME of 2,449 kcal/kg for beef meat and bone meal and 2,847 kcal/kg for pork meat and bone meal, while others found no differences in species (Karakas et al., 2001).

Use in rations

Animal proteins are a useful constituent of poultry rations. They provide a high level of protein/amino acids, highly available phosphorus, a number of other minerals and moderate amounts of energy. While historically there have been some limits on the use of animal products in poultry rations, most of these have been artificially set due to a lack of information. Much of that information is now available, and use of products is more closely tied to the economics of the products relative to competing products.

Before looking at some ideas and methodologies for using these protein products, let's examine some recent research relative to their use as there has been confusion that deserves explanation. When looking at the results of a variety of trials, one sees everything from a positive response to no response to a very negative response. While each of these responses can be found, an understanding of why the differential response occurs is needed.

Negative response: Animal protein meals have been used successfully in the U.S. and around the world for a number of years with excellent results. Why, then, are there data that show a negative response to their dietary incorporation? There are several reasons for this.

In some cases, the research was poorly designed. An example of this might be the use of an energy value that was higher than the actual value of the product, which would result in an actual decrease in dietary energy as more of the product was added to the diet. Probably, the main reason for poor results from trials using animal protein meals is that diets were not formulated on a digestible amino acid basis. When this occurs, if formulations are very close to the actual requirement, a deficiency of an amino acid can be inadvertently created. This can occur if a highly digestible ingredient is replaced with one lower in digestibility.

The example diet in Table 2 is a starter turkey ration that compares a corn-soybean meal diet with one in which a meat product has been added to the ration. Note the 5% reduction in available lysine and the 15% reduction in methionine. As long as nutrients are overfed, which is a common practice, this will not be an issue since the requirements of the animal are still being met. However, as the industry moves toward more precise feeding methodology (precision feeding), this is certainly an issue.

Obviously, when formulating on a digestible basis, no depression in growth should occur.

Another cause of a negative response would be a nutrient imbalance (usually seen only at high inclusion levels without constraints) whereby several nutrients become out of balance due to the levels found in the meat and bone meal itself. An example of this might be the calcium-to-phosphorus ratio. Meat meal may provide a significant portion of these nutrients, but not necessarily in the correct ratio for the diet. If this was not considered in the formulation matrix, negative results may occur.

Similar response: This is the most common research outcome and should be expected. A knowledgeable nutritionist should be able to get similar responses with a number of different ingredients. Use of animal protein products up to inclusion levels that would typically be cost effective, such as 12%

in a broiler starter diet, should result in similar performance when compared with diets that contain no animal products when formulation is based on the types of parameters mentioned above.

Positive response: In some cases, the addition of animal proteins to a diet will provide a positive response (i.e., improved growth rate). Assuming that diets, etc., were formulated correctly, the most likely cause of this is balancing of amino acid profile relative to the needs of the animal. This is something that occurred with fish meal addition (resulting in a perceived need for fish meal), and in fact, some companies that blend meals sought this effect.

Safety of byproducts

Rendering is a process of controlled heating to remove moisture, facilitate fat separation and produce aseptic material. Depending on the exact process, temperatures of 240-285°F at corresponding times provide for the inactivation of bacteria, viruses, protozoa and parasitic organisms. Animal protein meals have been stigmatized and more closely scrutinized for bacterial contamination, especially for salmonella, than other feed ingredients.

Salmonella are destroyed by heat when exposed to temperatures of 130°F for one hour or at 140°F for 15 minutes. Thus, the opportunistic and ubiquitous nature of salmonella and other pathogenic bacteria may re-contaminate products after cooking or processing, during storage and transport and handling.

Post-process contamination is of concern for all feed ingredients and is not restricted only to animal proteins. Davies and Funk (1999) completed an extensive review of salmonella epidemiology and control. This report, as well as other databases, suggests that all feed ingredients may be contaminated with salmonella (Table 3).

It is now recognized that feeds of plant origin, i.e., soybean meal and corn, are often contaminated with salmonella. The rendering process has been shown to be one of the most efficacious methods for processing the raw inedible byproduct materials from animal production. Incineration and alkaline/acidic digestion, though microbiologically effective, result in nutritional denaturation of the material. Rendering, which utilizes a time/temperature control process, preserves the nutrient contents of the derived ingredients.

Table 4 provides data that illustrate the high incidence and content of foodborne microorganisms within raw animal byproduct material (Troutt et al., 2001). Further, Table 4 provides data to demonstrate the efficacy of the rendering process in killing salmonella and other pathogenic bacterial organisms that may be present in raw animal byproducts.

In addition to the market interruption created by the North American diagnosis of BSE, the biosecurity and safety of animal byproducts have been under enhanced scrutiny. There has been no evidence of transmission of any of the transmissible spongiform encephalopathies to poultry, including BSE.

Oral challenges — BSE to chickens. The Veterinary Laboratories Agency, Webridge, U.K., under the direction of Dr. Danny Mathews (Mathews, 2001), conducted oral challenge studies using BSE-infected brain stems fed to chickens.

The oral challenge consisted of 5 g of infected tissue given by esphageal tube into the crop of broiler chickens at four, five and six weeks of age. For perspective, it is believed that 10 mg of infective brain tissue can initiate bovine infection. The challenged chickens were taken to a 57-month endpoint with no symptoms or infectivity in the birds' tissues.

Parental challenges — BSE to chickens. Studies were also conducted by Mathews incorporating intracranial and intraperitonal inoculations of infected bovine brain stem material into young male chickens.

The parental challenge consisted of 50µml intracranial and 1 ml intraperitoneal doses. Chickens were again taken to a 57-month endpoint. Chickens that showed any "motor disturbance" following inoculation were sacrificed and tissues sub-passaged back to chickens, observing any subclinical form of disease. Sub-passage in mice was also attempted. These studies were completed with confirmed negative findings.

The oral, intracranial and intraperitoneal inoculations provided extreme challenge not perceived to represent natural exposure. The research was conducted using raw nervous system tissue when, in actuality, food or feed ingredients are heat processed. Research has shown that heat does not destroy the infective agent but does lower its infectivity by a number of log reduction factors.

Species-to-species feeding

An intensive literature search was conducted by Denton et al. (2003) to assess the scientific evidence that same-species feeding of properly processed animal byproducts posed any animal or human health risks. Aside from the currently accepted ruminant-to-ruminant prohibition as a preventive for BSE in cattle, there were no risks documented in the literature base to validate that species-to-species feeding practices should cause concern.

Many farm animals and domestic pets, including fish, show cannibalistic tendencies both under natural as well as modern production practices. Such practices in poultry are feather and tissue picking and preying on dead or weakened group mates. Many of these tendencies have been prevented or alleviated by including animal byproduct ingredients in the diet.

Animal byproduct ingredients, having been properly processed, have no physical resemblance to the preprocessed byproduct. The rendering process completely decharacterizes muscle, fat and other animal tissues into a protein-rich, granular-type textured meal and fats with specific nutritional components, having absolutely no resemblance to the raw material.

The term cannibalism is not an appropriate description for the feeding of animal byproduct ingredients.

In late 2003 through 2004, several countries, including the U.S. and Canada, experienced or are experiencing avian influenza disease outbreaks. Though little research has been conducted with the specific strains of the influenza virus, validation that the rendering process inactivates viral diseases has been completed.

Studies completed by Dr. Eugene Pirtle, Iowa State University, confirmed that the pseudorabies virus (PRV) was inactivated in properly processed meat and bone meal from naturally infected swine as well as tissue experimentally inoculated with PRV prior to processing via rendering (Pirtle, 1990). Viral isolation and disease transmission was not accomplished in the rendered meat and bone meal.

PRV belongs to the alphavirus subfamily of Herpesviridae, a family that includes viruses with broad host ranges with the ability to establish latent infections in specific host tissue. Thus, PRV has served as an appropriate model for other virus types. ■

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Feedstuffs

THE WEEKLY NEWSPAPER FOR AGRIBUSINESS

Ruminant meat meal may lower feed costs: Part 2

Animal byproducts, as a group, represent viable feed ingredients at prices that have traditionally been considered normal. When prices such as those found at the time of this writing for ruminant meat and bone meal occur, they can be a source of considerable cost savings for the poultry industry.

By JEFFRE FIRMAN, DAVID ROBBINS and GARY PEARL

In more recent years, the focus of nutrition has shifted away from providing maximum growth to providing the maximum cost efficiency, since growth has become relatively easy to obtain. While it is possible to provide too much of a nutrient and inhibit growth, cost issues dictate that this is rarely a real-world problem.

In the search for cost-efficient production, terms like "ideal protein," "precision feeding" and "best cost nutrition" are important as these will ultimately lead to the least cost per unit of gain. Animal protein meals fit into this cost-efficiency program as a well-priced protein source with other nutrients of value as well.

Taking a stepwise approach shows how a product such as ruminant meat and bone meal can be used:

(1) The first step toward use of any available products is to gather information on current pricing and nutrient specifications. This should be done based on known criteria, such as delivered to the mill in the form used by the mill.

(2) Next, gather information on the products with potential for use. We'll just use ruminant meat and bone meal as an example. The complete nutrient profile of the product, including digestible amino acid levels, will be needed if formulating on this basis.

(3) With the gathered information, we can then input data into the computer and take a look at the resulting price structure. In Table 1, we have gone through this exercise with prices for soybean meal set at $240 per ton and then set the meat and bone meal inclusion level at a percentage relative to this price since prices fluctuate based on market conditions. Nutrient specifications were set at National Research Council levels for a broiler grower.

With a straight corn-soybean meal diet, the example base price is $141.12. As meat and bone meal is added to the

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TABLE

1. Comparison of diets with differing levels and prices of meat and bone meal (MBM) expressed as a percentage of soybean meal price

	Price of meat meal relative to soybean meal, %					
	Base	110	100	90	84	<84*
Meat meal, %	—	6.05	7.70	7.70	7.70	++++
Calcium, %	0.90	0.90	0.90	0.90	0.90	+
Phosphorus, %	0.35	0.35	0.41	0.41	0.41	++++
Price, $ per ton	141.12	136.40	134.81	132.81	132.07	131.85

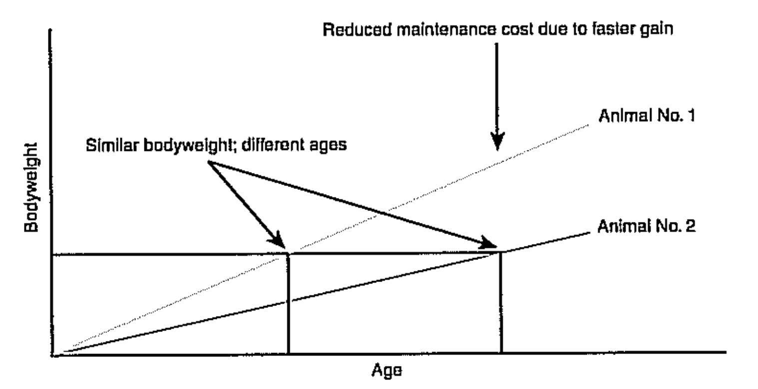
*Constrained at 10% MBM addition.

2. Mean ME comparisons for MBM products (kcal/kg)

System	Mean	SE	Significance
ME[1]	2,511[a]	24	None
TME[1]	2,487[a]	42	—
Collection	Mean	SE	Significance
Digesta[2]	2,409[b]	41	0.011
Excreta[2]	2,560[a]	29	—
Total[2]	2,487[ab]	42	—
Species	Mean	SE	Significance
Chicken	2,501[a]	29	None
Turkey	2,509[a]	30	—

[a,b]Means with no common letter are significantly different.
[1]ME system refers to battery-reared birds, and TME system refers to tube-fed birds.
[2]Digesta and excreta samples were collected from battery-reared birds and total samples were collected from tube-fed birds.

FIGURE



The basic production process of rendering.

TABLES

3. Proximate analysis and mineral composition of MBM products

Sample	Gross energy, Kcal/kg	Crude protein, %	Moisture, %	Fat, %	Ash, %	Calcium, %	Phosphorus, %	Potassium, %	Sodium, %	Iron, ppm
MBM-2	3,880	53.8	6.2	10.8	27.3	8.3	4.0	0.42	0.83	1,265
MBM-3	4,130	50.4	8.2	10.3	28.9	9.3	4.7	0.46	1.05	381
MBM-5	4,200	50.9	6.5	9.7	31.1	10.3	4.5	0.44	0.85	365
MBM-7	4,439	59.0	7.9	8.4	23.9	8.1	4.3	0.54	0.68	258
MBM-8	4,147	58.5	4.4	12.3	23.3	8.3	4.2	0.63	0.71	437
MBM-9	4,347	51.9	5.8	12.4	27.0	9.0	4.5	0.59	1.14	456
MBM-10	4,384	51.1	3.5	11.5	26.8	NA	NA	NA	NA	NA
MBM-12	3,516	48.3	6.3	8.2	27.3	11.8	5.9	0.40	0.92	564
MBM-13	3,728	52.4	7.8	12.1	23.6	7.5	3.8	0.64	1.04	724
MBM-14	3,779	50.1	5.0	8.6	34.2	12.1	6.0	0.47	1.11	228
MBM-15	4,349	58.9	5.2	9.4	25.7	8.9	4.6	0.63	0.88	401
MBM-16	3,077	45.7	7.0	9.0	37.7	13.6	6.8	0.33	1.10	226

4. Mean ME values for each assay method of each MBM product (kcal/kg)

	MBM-2		MBM-3		MBM-5		MBM-7		MBM-8		MBM-9	
Sample[1]	Mean	SE[2]	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Rooster TMEn	2,240^{bc}	90	2,469^{a}	74	3,026^{a}	61	3,329^{a}	131	2,547^{a}	86	3,356^{a}	97
Turkey TMEn	2,528^{ab}	81	2,517^{a}	74	2,600^{bc}	79	3,103^{ab}	131	2,585^{a}	86	2,669^{b}	97
Chick digesta AMEn	2,135^{c}	81	2,436^{a}	74	2,555^{c}	61	2,705^{b}	131	2,401^{a}	97	2,858^{b}	86
Chick excreta AMEn	2,508^{ab}	81	2,577^{a}	74	2,751^{abc}	61	3,038^{ab}	131	2,552^{a}	86	3,003^{ab}	86
Chick excreta aAMEn	2,475^{abc}	81	2,614^{a}	74	2,786^{abc}	61	3,081^{ab}	131	2,594^{a}	86	3,040^{ab}	86
Poult digesta AMEn	2,722^{a}	90	2,454^{a}	74	2,882^{ab}	69	2,863^{ab}	131	2,581^{a}	97	2,946^{ab}	137
Poult excreta AMEn	2,586^{ab}	90	2,510^{a}	74	2,975^{a}	61	2,888^{ab}	131	2,503^{a}	86	2,822^{b}	86
Poult excreta aAMEn	2,611^{ab}	90	2,534^{a}	74	3,004^{a}	61	3,103^{ab}	131	2,530^{a}	86	2,851^{b}	86
Significance	0.0007		None		<0.0001		0.058		None		0.0017	

[a,b,c]Means with no common letter are significantly different.
[1]TMEn = true ME nitrogen corrected; AMEn = apparent ME nitrogen corrected; aAMEn = apparent ME nitrogen corrected and adjusted for endogenous loss.
[2]Pooled standard error (SE) differs due to unequal number of experimental units.

5. Mean ME Values for each assay method of each MBM product (kcal/kg)

	MBM-10		MBM-12		MBM-13		MBM-14		MBM-15		MBM-16	
Sample	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Rooster TMEn	2,685^{a}	118	1,703^{b}	78	2,282^{a}	107	2,267^{a}	109	2,858^{ab}	135	2,106^{a}	122
Turkey TMEn	2,789^{a}	152	2,192^{a}	78	2,010^{a}	107	2,355^{a}	97	2,583^{ab}	120	1,854^{a}	136
Chick digesta AMEn	2,737^{a}	118	1,813^{b}	78	2,385^{a}	107	1,953^{a}	97	2,474^{b}	120	1,945^{a}	122
Chick excreta AMEn	2,820^{a}	118	2,168^{a}	78	2,013^{a}	107	2,332^{a}	97	3,079^{a}	120	1,588^{a}	122
Chick excreta aAMEn	2,861^{a}	118	2,204^{a}	78	2,052^{a}	107	2,369^{a}	97	3,123^{a}	120	1,623^{a}	122
Poult digesta AMEn	2,891^{a}	118	1,872^{ab}	78	2,330^{a}	107	2,067^{a}	97	2,785^{ab}	135	2,019^{a}	122
Poult excreta AMEn	2,791^{a}	118	1,975^{ab}	78	2,115^{a}	107	2,325^{a}	97	2,932^{ab}	120	2,017^{a}	136
Poult excreta aAMEn	2,811^{a}	118	1,999^{ab}	78	2,137^{a}	107	2,355^{a}	97	2,974^{ab}	120	2,045^{a}	136
Significance	None		0.0004		None		NS		0.0062		NS	

[a,b]Means with no common letter are significantly different.

diet, there is a cost savings, with the greatest savings at the highest level of addition and with a lower price than soybean meal.

Generally, meat and bone meal can be purchased for the same or lower price than soybean meal, and thus, cost savings from this can be substantial as shown with the diet containing meat and bone meal at 110% of soybean meal, which still resulted in savings. General savings over a corn-soybean meal diet will be in the 5% range, though savings as high as 10% have been noted.

Note that in diets where the meat meal price is less than 84% of the soybean meal price, a maximum constraint must be used, or the computer will use meat and bone meal as a total replacement of soybean meal. This constraint could be on calcium, available phosphorus or meat and bone meal itself.

(4) The next step is to look into the use of multiple products at the same time. In general, as one provides more choices (poultry byproduct meal, feather meal, etc.) to choose from, we see a more accurate nutrient balance (less excess nutrients fed) as well as cost savings. More information (Firman, 2003) on strategies for saving costs through the use of computer formulation is available.

TABLE

6. Mean ME values for each MBM product (kcal/kg)

Sample	Mean[1]	SE
2	2,518^{c}	47
3	2,514^{c}	46
5	2,781^{ab}	47
7	2,981^{a}	46
8	2,503^{c}	46
9	2,876^{ab}	47
10	2,758^{b}	47
12	1,984^{ef}	46
13	2,165^{de}	46
14	2,245^{d}	47
15	2,827^{ab}	47
16	1,894^{f}	48
Significance	< 0.0001	—

[a-f]Means with no common letter are significantly different.
[1]Mean is of all replicates of all methods for each sample. Prediction equations generated from the above data are as follows: MBM: MEn = 240.8 - 75.9 x carbohydrate + 47.8 x CP (R^2 = 0.42, using proximates); MBM: MEn = -978 - 59.3 x CHO + 0.9 x GE (R^2 = 0.77, using gross energy).

Energy determination

One of the concerns expressed when using meat and bone meal is the determination of energy content of the diet. Recent work by Firman examined a variety of methodologies used over the years to determine the energy content of feedstuffs. These data are presented in Tables 2-5.

While some differences occur by method, in most cases, all of the methods provided similar numbers. An equation that predicts energy values is included with Table 6.

Practical use of fats

Use of fats for animal feed has many advantages. In the authors' opinion, we tend to feed diets too low in energy and should probably utilize higher levels of energy based on pricing structures. Some benefits of fat addition are:

- Concentrated source of energy and the main method of increasing the energy content of diets;
- Increased growth rates;
- Increased feed efficiency;
- Decreased feed intake;
- Source of linoleic acid;
- Decreased dustiness of feeds and reduced dust losses;
- Lubricant for feed mill equipment;
- Increased palatability of feeds;
- Decreased age at market and increased throughput of housing systems due to increased growth rates;
- Useful lower heat increment during heat stress to keep caloric intake up;
- Slowed gut transit of other feeds, resulting in increased digestibility;
- Display of an "extra caloric" effect;
- Increased cost effectiveness than other energy sources;
- Concentrated feeds that can decrease transportation costs for feed delivery, and
- Use of higher levels of fat may negate the effects of pelleting.

Some concerns that should be noted with fat utilization include:

- Measurement of ME content can be somewhat difficult;
- There is a potential for rancidity;
- Equipment needs relative to fat additions must be adequate, and
- The young bird may have poor digestibility of saturated fats.

While this article is not intended to be a treatise on fat utilization, the Figure illustrates the principle behind much of the beneficial effects of fat. Basically, as we increase growth rate (through increased energy intake, for instance), we reduce our total costs for maintenance and improve efficiency.

Summary

Animal byproducts as a group represent viable feed ingredients at prices traditionally considered normal and can be a source of considerable cost savings for the poultry industry.

REFERENCES

Angkanaporn, K., V. Ravindran and W.L. Bryden. 1996. Additivity of apparent and true ileal amino acid digestibilities in soybean meal, sunflower meal and meat and bone meal for broilers. Poultry Science. 75:1098-1103.

Dale, N. 1997. Metabolizable energy of meat and bone meal. J. Appl. Poult. Res. 6:169-173.

Davies, P.R., and J.A. Funk. 1999. Proc. Third International Symposium on the Epidemiology and Control of Salmonella in Pork, Aug. 5-7. p. 1-11.

Denton, J.H., C. Coon, J. Pettigrew and C.A. Parsons. 2003. Historical and Scientific Perspective of Same Species Feeding of Animal By-Products. Fats & Proteins Research Foundation (FPRF) Directors Digest 322.

Dolz, S., and C. de Blas. 1992. Metabolizable energy of meat and bone meal from Spanish rendering plants as influenced by level of substitution and method of determination. Poult. Sci. 71:316-322.

Drewyor, M.A., and P.W. Waldroup. 2000. Utilization of high levels of meat and bone meal in broiler diets. J. Appl. Poult. Res. 9:131-141.

Elkin, R.G. 2002. Nutritional components of feedstuffs: a qualitative chemical appraisal of protein. Poultry Feedstuffs: Supply, Composition and Nutritive Value. CAB International, Wallingford, U.K.

Firman, J.D. 1992. Amino acid digestibilities of soybean meal and meat meal in male and female turkeys of different ages. J. Appl. Poult. Res. 1:350-354.

Firman, J.D. 2003. Diet Formulation Strategies for the Future in Poultry. National Renderers Assn. Johannesburg, South Africa.

Firman, J.D., and J.C. Remus. 1994. Fat additions increase digestibility of meat and bone meal. J. Appl. Poult. Res. 3:80-82.

Johns, D.C., C.K. Low, J.R. Sedcole, M.P. Gurnsey and K.A.C. James. 1987. Comparison of several *in vivo* digestibility procedures to determine lysine digestibility in poultry diets containing heat treated meat and bone meals. Brazilian J. Poult. Sci. 28:397-406.

Johnson, M.L., C.M. Parsons, G.C. Fahey Jr., N.R. Merchen and C.G. Aldrich. 1998. Effects of species raw material source, ash content and processing temperature on amino acid digestibility of animal byproduct meals by cecectomized roosters and ileally cannulated dogs. J. Anim. Sci. 76:1112-1122.

Karakas, P., H.A.J. Versteegh, Y. van der Honing, J. Kogut and A.W. Jongbloed. 2001. Nutritive value of the meat and bone meals from cattle or pigs in broiler diets. Poult. Sci. 80:1180-1189.

Martosiswoyo, A.W., and L.S. Jensen. 1988a. Available energy in meat and bone meal as measured by different methods. Poult Sci. 67:280-293.

Martosiswoyo, A.W., and L.S. Jensen. 1988b. Effect of formulating diets using differing meat and bone meal energy data on broiler performance and abdominal fat content. Poult Sci. 67:294-299.

Mathews, D. 2001. U.S. Department of Agriculture-Agriculture Research Service BSE Workshop Meeting, March 15. Rockville, Md.

Mendez, A., and N. Dale. 1998. Rapid assay to estimate calcium and phosphorus in meat and bone meal. J. Appl. Poult. Res. 7:309-312.

Parsons, C.M., F. Castanon and Y. Han. 1997. Protein and amino acid quality of meat and bone meal. Poult. Sci. 76:361-368.

Pirtle, E.C. 1990. Stability of Pseudorabies Virus (PRV) in Meat and Bone Meal and Intermediate Rendering Products. FPRF Directors Digest 203.

Sell, J.L. 1996. Influence of dietary concentration and source of meat and bone meal on performance of turkeys. Poult. Sci. 75:1076-1079.

Sell, J.L., and M.J. Jeffrey. 1996. Availability for poults of phosphorus from meat and bone meals of different particle sizes. Poult. Sci. 75:232-239.

Shirley, R.B., and C.M. Parsons. 2000. Effect of pressure processing on amino acid digestibility of meat and bone meal for poultry. Poult. Sci. 79:1775-1781.

Shirley, R.B., and C.M. Parsons. 2001. Effect of ash content on protein quality of meat and bone meal. Poult. Sci. 80:626-632.

Troutt, H.F., D. Schaeffer, I. Kakoma and G.G. Pearl. 2001. Prevalence of Selected Foodborne Pathogens in Final Rendered Products. FPRF Directors Digest 312.

Wang, X., and C.M. Parsons. 1998a. Bioavailability of digestible lysine and total sulfur amino acids in meat and bone meals varying in protein quality. Poult. Sci. 77:1003-1009.

Wang, X., and C.M. Parsons. 1998b. Dietary formulation with meat and bone meal on a total versus a digestible or bioavailable amino acid basis. Poult. Sci. 77:1010-1015.

Wang, X., F. Castanon and C.M. Parsons. 1997. Order of amino acid limitation in meat and bone meal. Poult. Sci. 76:54-58.

Waring, J.J. 1969. The nutritive value of fish meal, meat and bone meal and field bean meal as measured by digestibility experiments on the adult colostomised fowl. Brazilian J. Poult. Sci. 10:155-163. ■