RENDERED PRODUCTS IN RUMINANT NUTRITION

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Summary

The recycling of rendered animal products back into the feed of ruminant livestock species has had a positive impact both on the efficiency of livestock production and the availability of meat and milk for consumers at an affordable price. Rendered animal products are distinguished by a high protein content containing amino acids that resist microbial degradation in the rumen, and for extracted animal fats that supply high energy for meat and milk production.

Historically, the primary rendered animal products used as protein supplements include meat and bone meal, blood meal, fish meal, and feather meal. Regulations by the U.S. Food and Drug Administration (FDA) in response to concerns about bovine spongiform encephalopathy (BSE) will dictate the continued use of some rendered animal products as feed ingredients for ruminant diets. Current restrictions prohibit feeding meat and bone meal from rendered ruminant species back to cattle and sheep, but no restrictions have yet been placed on blood meal or feather meal. Concerns about cattle-based protein supplements have elevated interest in rendered poultry meals, including feather meal and poultry meat by-products for cattle rations.

Rendered animal products with high fat content include tallow and greases. With the majority of lipid material in rendered fats consisting of triglycerides containing 90 percent fatty acid content or higher, energy densities of rendered fats equals or exceeds the energy content of most fat supplements used routinely in cattle rations. The high energy density combined with reasonable pricing makes rendered fats competitive with most other feed fats on a cost per unit of energy basis. The major limitations of fats extracted from animal products include their need for specialized transport and mixing equipment, and their potential to disrupt microbial fermentation in the rumen possibly leading to reduced feed digestibility.

Protein Contributions of Rendered Animal Products

Regulatory Concerns

Rendered animal products have contributed immensely to meeting the protein needs of ruminant livestock species for many decades without health concerns to the animal or to human consumers. The heat treatment applied to rendered animal products to remove moisture was sufficient to kill bacterial and viral infectious agents. The advent of concerns about BSE, commonly referred to as "mad cow disease," that first occurred in Europe, led to an FDA ban in the United States in 1997 that prevented feeding cattle and sheep any meat and bone meal product rendered from ruminant species. The first case of BSE appeared in the

United States in 2003 (imported from Canada) and a third case was reported in 2006. Concerns remain elevated about the cause and prevention of the disease, which is usually attributed to a prion rather than a bacteria or virus. Prions are pieces of normal cell proteins that can replicate to a disease form, but withstand usual inactivation treatments such as pH extremes, radiation, or formalin exposure.

Clearly, continued use of rendered animal products as protein supplements for cattle and sheep diets hinges on current and future FDA regulations. Although ruminant meat and bone meal was affected by the FDA ban, blood meal, and feather meal were not affected. Also, it is still permissible to feed cattle meat and bone meal originating from pork or poultry products. As a result, interest has grown in feeding more rendered poultry products to cattle, as will be discussed later. Additional FDA restrictions will determine the extent and types of rendered animal products available as protein supplements for cattle and sheep rations. Readers can obtain more information about the impact of FDA regulations on using rendered animal products as livestock feed ingredients at the National Renderers Association Web site (www.renderers.org).

Protein and Amino Acid Composition

Rendered animal products are distinguished by a high protein content containing amino acids that resist microbial degradation in the rumen (Figure 1). The portion of feed protein that escapes microbial breakdown is referred to as rumen undegradable protein (RUP). The RUP fraction carries intact feed amino acids directly to the small intestines of the ruminant animal where they are digested and absorbed. The RUP fraction may favor high meat and milk production if it contains proper proportions of essential amino acids needed for protein synthesis in body tissues. A high RUP fraction may be detrimental if it contains amino acids not needed by body tissues, or its constituent amino acids are not digested well in the small intestines.

The rumen degradable protein (RDP) fraction in feed is subjected to proteolysis by ruminal microorganisms yielding amino acids and peptides. Amino acids are subsequently degraded to ammonia plus organic acids. The ammonia has three possible outcomes: (1) absorption across the ruminal epithelium into blood, (2) passage to the small intestine, and (3) utilization by ruminal microorganisms to synthesize microbial protein which in turn passes to the small intestine for digestion and absorption. Ammonia reaching the blood may be excreted from the animal's body in urine where it has no further opportunity to meet the animal's protein needs.

Although more than 100 rendered animal products are defined by the Association of American Feed Control Officials (AAFCO), the major products used as protein supplements for livestock rations include meat and bone meal, meat meal, poultry and poultry by-product meal, blood meal, feather meal, and fish meal. Those of greatest importance for ruminant diets are shown in Table 1 along with their total protein and RUP contents. Protein contents range from 54 percent for meat and bone meal to 96 percent for blood meal. The majority of protein in rendered products is RUP, which ranges from 55 percent of crude protein (CP) for meat meal to 78 percent of CP for blood meal.

Figure 1. Rumen Nitrogen Metabolism—RUP that Passes Directly to the Small Intestines versus RDP that Either is Converted to Microbial Protein or is Excreted in Urine.

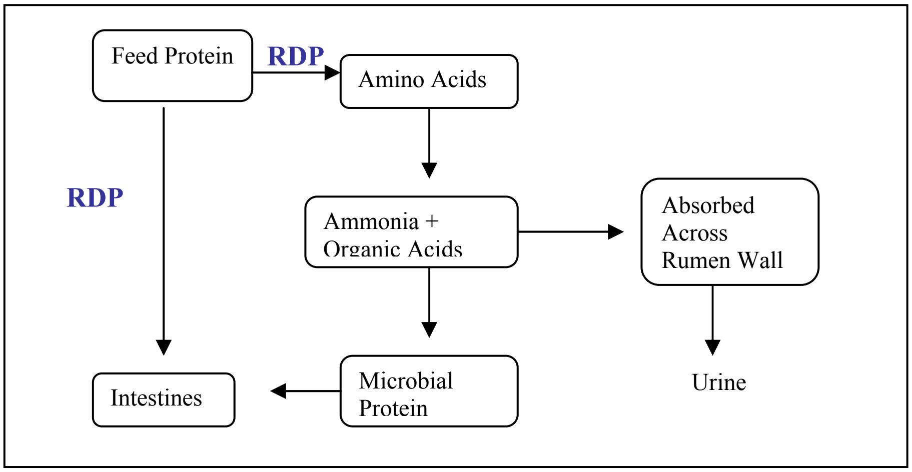


Table 1. Total CP Contents and RUP Fractions of Major Rendered Animal Products Used as Feed Ingredients for Beef and Dairy Feeds.

	CP, as % dry matter		RUP, % CP	
	Beef[a]	Dairy[b]	Beef	Dairy
Blood Meal	93.8	95.5	75.0	77.5
Feather Meal	85.8	92.0	70.0	65.4
Fish Meal[c]	67.9	68.5	60.0	65.8
Meat and Bone Meal		54.2		58.2
Meat Meal	58.2		55.0	

[a] From NRC requirements for Beef Cattle, 1996.

[b] From NRC requirements for Dairy Cattle, 2001. Example RUP data were based on feed intake of 4% body weight and 50% forage.

[c] Menhaden fish as reported in NRC for Dairy Cattle, 2001.

The high RUP concentration is due to heat treatment of the rendered products to remove moisture and facilitate fat extraction. Heating denatures proteins and lowers their water solubility, which substantially reduces their rate of microbial proteolysis. At any given rate of feed particle passage through the rumen, slower proteolytic rates translate into greater escape of feed protein from microbial breakdown. A recent study showed that the RUP value of rendered animal products remains high across a wide range of feeding rates (Legleiter et al., 2005).

Aside from high total crude protein and RUP contents, equally important to the high nutritional value of rendered animal products is the amino acid profile (Table 2). Blood, feather, and fish meals all contained at least five essential amino acids in higher concentrations than are found in soybean meal. Also, the amino acids in these rendered animal products were 58 to 78 percent RUP compared to only 43 percent RUP in soybean meal.

Table 2. Essential Amino Acid Profile (Percent CP) of Major Dried and Ground Meals from Rendered Animal Products Used as Feed Ingredients for Beef and Dairy Feeds versus the Amino Acid Profile of Soybean Meal.[a]

Amino Acid	Blood	Feather	Fish	MBM	Soybean
Arg	4.38	6.93	5.82	6.98	7.32
His	**6.36**[b]	1.15	**2.83**	1.89	2.77
Ile	1.26	**4.85**	4.09	2.76	4.56
Leu	**12.82**	**8.51**	7.22	6.13	7.81
Lys	**8.98**	2.57	**7.65**	5.18	6.29
Met	1.17	0.75	**2.81**	1.40	1.44
Cys	1.28	**5.09**	0.91	1.01	1.50
Phe	**6.85**	4.93	3.99	3.36	5.26
Thr	**4.34**	**4.73**	**4.20**	3.27	3.96
Try	**1.59**	0.73	1.05	0.58	1.26
Val	**8.68**	**7.52**	**4.82**	4.20	4.64

[a] From NRC for Dairy Cattle, 2001.
[b] Amino acid concentrations shown in bold were higher for rendered animal products than for soybean meal.

New Information on Poultry Meals for Ruminant Diets

With the current FDA ban on feeding meat and bone meal (rendered from ruminants) back to cattle and sheep, and the uncertainty surrounding future FDA restrictions on rendered animal products, interest has grown in the nutritional benefits of poultry products in ruminant feeds. One recent effort was a re-evaluation of the nutritional value of feather meal as a feed ingredient for cattle rations (Cotanch et al., 2006). Representative samples of feather meal were taken each day for five days from 15 plants that covered approximately 85 percent of total U.S. feather meal production. Processing information was recorded including heating conditions (time, temperature, and pressure), percentage blood added, and batch versus continuous flow processing.

Among the 15 plants that provided samples for the Cotanch et al. (2006) article, six produced feather meal without blood, and the remaining nine produced feather meal with added blood. Nutrient content of feather meal was consistent among plants within a feather meal category, i.e., the product produced without blood was consistent from plant-to-plant and the product with blood also was consistent in composition from plant-to-plant. The addition of blood, however, influenced nutrient composition of the final product (Table 3). Blood addition to feather meal had no effect on total protein or fat contents, but ash content was higher and the acid detergent insoluble crude protein (ADICP) was lower for product with added blood. The ADICP, or protein bound in the acid detergent fiber fraction, is an estimate of the indigestible protein fraction. Thus, the addition of blood to feather meal increases total tract digestibility of protein. Blood addition had an effect on essential amino acids, but not on individual fatty acids. Methionine and lysine, generally regarded as the most limiting amino acids for meat and milk production, were both higher in the feather meal product containing added blood.

Table 3. Nutrient Composition of Feather Meal with and without Added Blood. [a]

	Feather meal		
	No Blood	**Added Blood**	**SEM** [b]
Dry Matter, %	93.3	93.5	0.9
Crude Protein, %	87.8	87.8	1.1
Ether Extract, %	10.0	9.5	0.9
Total Fatty Acids, %	7.3	6.8	0.7
Ash, %	1.9	2.6	0.2*
NDICP, %CP	49.9	51.2	4.0
ADICP, %CP	26.5	18.9	2.7*
Amino Acids, % of total amino acids			
Arg	6.88	6.73	0.03*
His	0.74	1.28	0.07*
Ile	4.80	4.79	0.03
Leu	8.21	8.54	0.06*
Lys	2.12	2.90	0.11*
Met	0.70	0.77	0.03*
Cys	5.47	5.15	0.33
Phe	4.91	5.10	0.04*
Thr	4.58	4.60	0.03
Try	0.57	0.66	0.04*
Val	7.54	7.56	0.07
Major Fatty Acids, % of total fatty acids			
C14	1.09	1.06	0.05
C16	24.3	25.4	0.3*
C18	8.3	8.9	0.4
C18:1	32.5	32.0	0.6
C18:2	13.2	10.4	0.6
C18:3	0.54	0.34	0.05

* Effect of blood addition ($P < 0.05$)
[a] From Cotanch et al. (2006).
[b] SEM is standard error of measurement.

Another recent effort to utilize rendered poultry nutrients more efficiently for ruminant diets was the development of a new process to reclaim nutrients from the process water of poultry processing plants. The process water from poultry processing plants contains considerable organic nutrients that must be captured, stored, treated, and disposed of in a manner that prevents environmental contamination. As an alternative, nutrients in the process water could be recycled as a feed supplement for ruminants. Because poultry process water has a high fat content containing unsaturated fatty acids, there is concern that it could inhibit ruminal fermentation, causing reduced feed digestibility. A novel process has recently been developed by Simmons Foods, Inc. (Siloam Springs, AR) to reclaim nutrients from the process water by reacting organic matter to yield a dry, free-flowing product called PRO*CAL, which possibly may reduce or eliminate negative effects on fermentation. The final product contains about 47 percent crude protein that is consistently more than 70 percent RUP. Animal studies showed that PRO*CAL could be fed to lactating dairy cows as a poultry-based source of bypass protein and fat without negative effects on feed intake or milk production (Freeman et al., 2005). Also, PRO*CAL had the added advantage over other bypass protein supplements of enhancing milk yield, presumably due to its higher fat and energy values. Additional studies done in continuous cultures of mixed ruminal microorganisms showed that PRO*CAL did not disrupt ruminal fermentation and had lower biohydrogenation of unsaturated fatty acids when compared to an equal amount of soybean oil (Jenkins and Sniffen, 2004). Thus, unlike poultry fats having a higher concentration of unsaturated fatty acids, the PRO*CAL product could be used as a dairy feed supplement without significant negative effects on ruminal fermentation.

Table 4. Uses and Reported Benefits of Additional Fat in Ruminant Rations.

Fat Use	Benefits
Increase diet energy density	Increase meat and milk production
Reduce metabolic heat loss	Elevate feed intake and production in hot, humid climates
Reduce dustiness and particle separation of mixed feeds	Improve feed handling and safety
Alter fatty acid profile of meat and milk	Conform to published nutritional guidelines for humans and enhance consumption of animal food products
Enhance tissue delivery of unsaturated fatty acids	Enhance metabolic and physiological functioning such as improved reproductive performance and immunity

Fat Contributions of Rendered Animal Products

Fat products from animal rendering continue to be used extensively as feed ingredients for a variety of livestock species, including ruminants. Table 4 lists a multitude of investigated uses and benefits of adding fat to cattle and sheep rations.

The core reason for adding fat to ruminant diets has been energy. Over the last 25 years, dairy has received more attention in feeding fat than beef due to higher pressures for maintaining adequate fiber intakes. Increasing energy by replacing forages with cereal grains reached an upper limit in many dairy operations, as low-fiber intakes were associated with increased incidence of several digestive and metabolic diseases. Adding fat to the ration provided an alternative means of increasing diet energy density without appreciably lowering fiber content. Fats are generally chosen for inclusion in cattle diets based on their cost, availability, handling characteristics, and animal performance. Animal performance issues include how the fat source affects feed intake, influence of the fat source on digestion in the rumen, and how the fat supplement itself is digested and absorbed in the intestines of the animal.

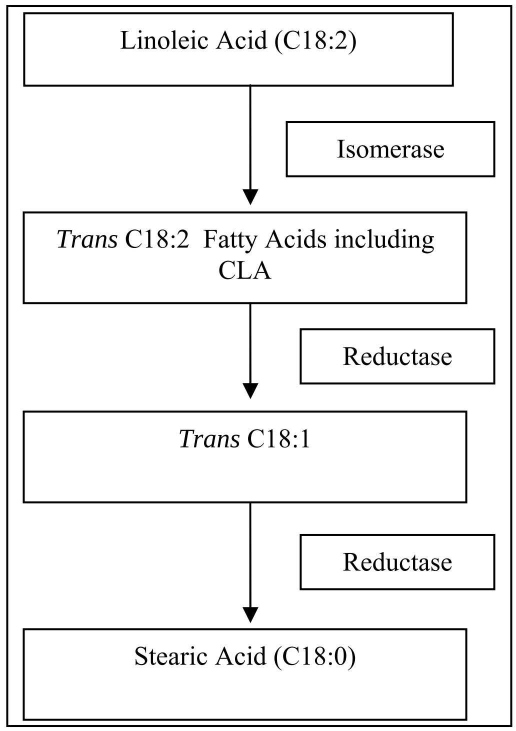
Figure 2. Reported Reproductive Benefits of Feeding Additional Fat to Dairy Cows During Established Lactation (Petit, 2003).

- Increase diameter of the corpus luteum
- Increase progesterone concentration
- Increase synthesis of series 3 prostaglandins from DHA and EPA
- Inhibit cyclooxygenase activity and $PGF_{2\alpha}$ synthesis – prevent regression of corpus luteum and increase fertility rates

As the production virtues of fat supplements in dairy and beef rations were being explored, questions arose about the usefulness of fat to help alleviate heat stress. Metabolism studies in many animal species confirmed that fat yielded lower metabolic heat losses compared to carbohydrate or protein on an equal calorie basis. Thus, it was an attractive idea to replace carbohydrate with fat as a means to elevate energy intakes in hot climates without any additional metabolic heat load. However, because fat levels were limited to relatively low concentrations in the diet, the metabolic heat savings was minimal. Until higher levels of fat are fed to cattle, little merit can be given to its contribution to alleviation of heat stress.

In the last 10 years, more attention has been directed at uses of fat supplements in cattle rations that were not associated with its energy value. These noncaloric functions were focused on increasing the delivery of unsaturated fatty acids to body tissues either to alter the nutritional value of meat and milk, or to meet tissue demands for essential fatty acids. For instance, positive responses in reproductive performance in cattle were reported at several locations when rumen-protected polyunsaturated fatty acids were added to the diet (Figure 2). Fat supplements that compete for these noncaloric functions, such as improved reproductive performance, must satisfy two criteria: (1) they must contain an appreciable quantity of the desired polyunsaturated fatty acid, and (2) the polyunsaturated fatty acids must resist destruction by ruminal microorganisms which occur via the process of biohydrogenation. Biohydrogenation causes rapid and extensive loss of double bonds in dietary unsaturated fatty acids (Figure 3) through an enzymatic reduction process that is carried out by microorganisms in the stomach of cattle, mainly in the rumen compartment.

Figure 3. Major Steps in Biohydrogenation of Linoleic Acid by Ruminal Microorganisms.



Energetic Benefits and Limitations of Rendered Fats for Cattle Rations

With the majority of lipid material in rendered fats consisting of triglycerides containing 90 percent fatty acid content or higher, energy densities of rendered fats equals or exceeds the energy content of most fat supplements used routinely in cattle rations. The high energy density combined with reasonable pricing makes rendered fats competitive with most other feed fats on a cost per unit of energy basis. Further consideration of rendered fats as supplements for ruminant diets are largely based on their convenience and animal performance characteristics. Convenience issues include availability of the product in some geographical locations, but mostly center on the need for specialized equipment for transporting and mixing semi-solid or liquid oils at farm locations. Many competing commercial fat sources have higher cost, but process the fat into a dry, free-flowing powder for easier transport and on-farm mixing.

Energy value of the fat supplement only partially explains reported variation in animal performance. Production is only improved if the added fat increases digestible energy (DE) concentration of the whole diet. All fat sources are grouped together in National Research Council (NRC) recommendations for beef cattle (1996) with an assigned DE value of 7.30 Mcal/kg (Table 5). The NRC recommendations for dairy cattle (2001) divided fat sources into five categories that range in DE value from 7.70 Mcal/kg for vegetable oils to 4.05 Mcal/kg for partially hydrogenated tallow.

Table 5. The Total Digestible Nutrient (TDN) and Digestible Energy (DE) Values for Fats Reported by NRC for Beef and Dairy Cattle.

	TDN, Percent	DE, Mcal/kg
NRC for Beef (1996)	177	7.30
NRC for Dairy (2001)		
Calcium soaps	163.5	6.83
Hydrolyzed tallow	176.3	7.37
Partially hydrogenated tallow	96.6	4.05
Tallow	147.4	6.17
Vegetable oil	184.0	7.70

More important than the fat DE value is the increase in total ration DE resulting from the addition of a fat source. Fat supplements may fail to elevate total ration DE if the fat reduces feed intake, reduces carbohydrate digestibility, or if their constituent fatty acids are poorly digested. The extent of these potential limitations will be discussed briefly for rendered fats.

Animal Fat Effects on Feed Intake

Fat added to dairy rations can reduce feed intake, which can greatly reduce or even eliminate a positive production response. Even as little as 0.5 kg less feed intake can neutralize any energy advantage coming from typical levels of added fat, thus preventing a positive milk production response. Reductions in feed intake have been reported for a wide variety of fat sources, and often the intake depressions are less severe for rendered fats than for vegetable oils or some commercial fat supplements. Across a summary of more than 20 dairy studies feeding tallow or grease, only two studies showed significant depressions in feed intake (Allen, 2000). A more recent summary of the literature by Onetti and Grummer (2004) showed that the intake effects of tallow were dependent on forage source. Tallow added to corn silage diets reduced intake and failed to increase milk production. However, a positive milk production response was seen when tallow was fed in alfalfa-based diets, or in diets with similar alfalfa and corn silage proportions.

Several causes for the depression in feed intake by added fat are under consideration. These include reduced gut motility, reduced acceptability of diets with added fat, release of gut hormones, and oxidation of fat in the liver (Allen, 2000). Refer to Allen (2000) for a description of each factor and a comparison of fat sources. Gut hormones continue to receive considerable attention as regulators of food intake. Depressed feed intake in cows fed fat supplements has been attributed to changes in cholecystokinen (Choi and Palmquist, 1996) and glucagon-like peptide 1 (Benson and Reynolds, 2001). Other peptides of gut origin, such as peptide YY, pancreatic glucagons, glicentin, and oxyntomodulin, have been linked to reduced feed intake patterns in animals fed fat (Holst, 2000). Past work has shown that abomasal infusion of unsaturated fatty acids causes greater feed intake depression than infusion of saturated fatty acids (Drackley et al., 1992; Bremmer et al., 1998). A recent study by Litherland et al. (2005) showed that the intake depression was greater following abomasal infusion of unsaturated free fatty acids than it was following infusion of unsaturated triglycerides. Also, as intake declined in the study by Litherland et al. (2005), the concentration of plasma glucagon-like peptide 1 increased but plasma concentration of cholecystokinen did not change.

Animal Fat Effects on Ruminal Fermentation and Digestion

Fat supplements must be limited to just a few percent in ruminant diets to avoid ruminal digestibility problems resulting from antimicrobial activity of their constituent fatty acids. Fat sources that have the potential to cause ruminal fermentation problems are referred to as rumen-active fats. Antibacterial effects of fatty acids in the rumen are complex and depend on interrelationships among fatty acid structure, fatty acid concentration, the presence of feed particles, and rumen pH (Jenkins, 2002). Fatty acid structural features that enhance antibacterial activity in the rumen include a free acid group on the carbon chain and the presence of one or more double bonds. Therefore, enhancing free fatty acids and fatty acid unsaturation in rendered fat sources generally reduces the amount that can be included in cattle diets. Several commercial fats minimize ruminal fermentation problems by enhancing the concentration of the less antibacterial saturated fatty acids. These are referred to as rumen-inert fats to signify their lower antimicrobial effects in the rumen.

Unsaturated fatty acids typically range from a low of about 48 percent in beef tallow to as much as 70 percent of total fatty acids in poultry fat (Table 6). Lard and pork greases are intermediate in percentage of total unsaturated fatty acids. Oleic acid concentration is similar across animal fat sources, meaning that most of the variation in percentage of unsaturated fatty acids is due to variation in polyunsaturated fatty acids (linoleic and linolenic acids).

Table 6. Fatty Acid Composition of Rendered Animal Fats in Order of Increasing Unsaturation (Rouse, 2003).

Fatty Acid	Beef Tallow	Lard	Pork Grease	Poultry Fat
Myristic	3.0	1.5	1.5	1.5
Palmitic	25.0	27.0	23.0	21.0
Palmitoleic	2.5	3.0	3.5	6.5
Stearic	21.5	13.5	11	8.0
Oleic	42.0	43.4	40.0	43.0
Linoleic	3.0	10.5	18.0	19.0
Linolenic		0.5	1.0	1.5
Saturated	49.5	42.0	35.5	30.0
Unsaturated	47.5	57.4	62.5	70.0

A simple equation to estimate the upper limit of rumen-active fat in dairy cattle rations was suggested by Jenkins and Chandler (1998) as Equation 1:

Rumen-Active Fat (percent of ration DM) = 4 x NDF/UFA
Where,
NDF = neutral detergent fiber concentration of total mixed ration
UFA = sum of oleic, linoleic, and linolenic acids in supplemental fat

Table 7. Maximum Amounts of Rendered Animal Fats for Inclusion in Dairy Rations Estimated from Equation 1.

	Beef Tallow	Lard	Pork Grease	Poultry Fat
UFA	45.0	54.4	59.0	63.5
Percent Fat[a]				
NDF=25	2.22	1.84	1.69	1.57
NDF=35	2.93	2.43	2.24	2.08
g Fat/day[b]				
NDF = 25	660	552	507	471
NDF = 35	879	729	672	624

[a] Percent Added fat in ration DM covering the range of NDF concentrations for dairy rations recommended by NRC (2001).
[b] Grams of added fat per day covering the range of NDF concentrations for dairy rations recommended by NRC (2001), assuming DM intake = 30 kg/day.

According to Equation 1, higher concentrations of rendered fats can be fed to dairy cattle by increasing either fat saturation or diet fiber concentration. For instance, recommended levels of rendered fats for dairy cattle consuming diets with 25 percent NDF vary from 2.22 percent for tallow down to 1.57 percent for the more unsaturated poultry fat (Table 7). Increasing diet NDF concentration from 25 to 35 percent increases recommended feeding levels of all rendered fat sources, but increases it the most for the more saturated beef tallow. Because feeding rates of saturated fats are higher in cattle rations, several rumen-inert fat sources have been developed from partial hydrogenation of animal fats to reduce unsaturation and improve handling.

Intestinal Digestibility of Rendered Animal Fats

Low intestinal digestibility of fatty acids in fat supplements can be another factor reducing their DE value for ruminant diets. Differences in DE values among fat sources published in NRC recommendations for dairy cattle (2001) are due mainly to differences in their true digestibilities. True digestibilities assumed by the NRC ranged from a high of 86 percent for vegetable oils and calcium salts to a low of 43 percent for partially-hydrogenated tallow. Tallow was assigned an intermediate digestibility of 68 percent by the NRC.

It was not surprising, based on results from previous studies, that feeding partially hydrogenated tallow reduced fatty acid digestibility. Hydrogenation of yellow grease to reduce its iodine value (IV) from 56 to 18 reduced apparent fatty acid digestibility in the total tract from 67.8 to 47.4 percent (Jenkins and Jenny, 1989). Fatty acid digestibilities pooled from 11 studies were normal (similar to control values) when IV exceeded 40, (Firkins and Eastridge, 1994), but below IV 40 fatty acid digestibility progressively dropped as IV declined.

Lower digestibility of hydrogenated fats may be related to their higher content of saturated fatty acids. The presence of one, two, or three double bonds increased fatty acid digestibility a similar amount. Grummer and Rabelo (1998) also reported similar improvements in apparent fatty acid digestibility from the presence of one or more double bonds. True digestibility of stearic acid was 53 percent and lowest among the 18 carbon fatty acids. Introducing a single double bond improved true digestibility to 78.4 percent. It should be pointed out that some studies did not distinguish between flows of *cis* or *trans* 18:1 to the duodenum. Lower 18:1 digestibilities may result from *trans* 18:1 flows.

Because of the lower true digestibility coefficient and energy value of tallow reported in NRC recommendations for dairy cattle (2001), the Fats and Proteins Research Foundation commissioned an independent review of the literature to examine digestibility of tallow versus other fat supplements for dairy cattle[1]. The final report revealed several discrepancies in the literature. First, several studies reported feeding tallow to dairy cows in digestibility trials, but the reported fatty acid compositions suggested that greases were the more likely fat source. Second, some studies reported examining the digestibility of tallow when in fact a mixture of fat sources was included in the diet.

The final report summarized fatty acid digestibilities from studies that included data only on lactating dairy cows fed a control diet with no high fat ingredients, and fat sources that were not combined with other fats. A total of 32 published studies met all criteria and 45 studies were rejected. The selective criteria limited the number of observations for some fat sources, especially oilseeds and vegetable oils that were usually fed in combination with other fat sources.

Among the fat sources examined, only tallow and calcium salts of palm fatty acids had mean total tract digestibilities that were numerically higher than the control diets (Table 8). The ranking was similar when digestibilities of the fat sources were estimated by difference. Conversely, the hydrogenated fat sources had substantially lower fatty acid digestibilities whether expressed as apparent digestibilities or were calculated by difference. The hydrogenated fat sources also had the highest standard deviations suggesting that wider variation exists in digestibility values of hydrogenated fats compared to other fat sources. Further examination of the data showed that about 80 percent of the hydrogenated fat cases depressed diet fatty acid digestibilities more than five percent. Tallow depressed diet fatty acid digestibilities more than five percent from control fatty acids in only 27 percent of the cases examined.

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[1] An independent literature review and opinion of the digestibility of tallow compared to other fat sources was prepared for FPRF by Dr. Tom Jenkins.

Table 8. Fatty Acid Digestibilities of Control Diets or Diets with Added Fat Summarized from 32 Published Studies with Lactating Dairy Cattle.

		Apparent Digestibilities[a]		Fat Digestibilities by Difference[b]	
	n[c]	Mean	SD[d]	Mean	SD
Control	32	72.3	7.7		
Tallow	11	73.9	8.5	72.8	13.2
Hydrogenated Fat	24	62.8	9.0	53.7	17.4
Oilseeds	6	66.4	8.4	54.0	20.8
Vegetable Oils	9	63.5	7.2	61.6	9.4
Calcium Salts	15	74.3	8.9	80.1	12.1

[a] Fatty acids digested across the entire digestive tract as a percentage of fatty acids consumed.
[b] Fatty acids in the basal diet were subtracted from the feed and feces to estimate digestibility of only the added fat source.
[c] Number of studies = n.
[d] Standard deviation.

The Future for Rendered Animal Products as Feed Ingredients for Ruminants

There remains a growing need in both beef and dairy rations for products that can supply RUP containing the essential amino acids needed for growth and milk production. Rendered animal products were positioned well in the past to meet critical amino acid needs with a consistent and affordable product. Regulatory issues surrounding BSE have suddenly emerged in recent years and cast doubt on their future. Undoubtedly, the use of rendered products from ruminant species being fed back to cattle and sheep will be limited. Perhaps interest will grow in utilizing rendered products from non-ruminant species, as is already occurring with poultry-based products.

Fat products derived from rendered animal products appear to be affected less by BSE-driven restrictions. However, tallow and greases from rendered animal products face an increasing competitive market of specialized animal fat sources. In ruminants, fats are looked upon more and more for supplying specific polyunsaturated fatty acids to tissues rather than just as energy sources. While the high energy value of rendered animal fats cannot be overlooked, innovative applications of animal fats for non-energy uses must emerge.

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