NORTH AMERICAN RENDERING

The Source of Essential, High-Quality Products

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Second Edition

NATIONAL RENDERERS ASSOCIATION, INC.

Contents

The North American rendering industry is a major force in maintaining a clean environment: Every year it recycles approximately 59 billion pounds of perishable material generated by the livestock and poultry meat/poultry processing, food processing, supermarket and restaurant industries. The rendering industry turns this material into valuable ingredients for various soaps, paints and varnishes, cosmetics, explosives, toothpaste, pharmaceuticals, leather, textiles, and lubricants. In fact, the industry returns the majority of its finished products to the feed industry in the form of high-energy fats and high-quality protein ingredients that supplement the diet and enable efficient production of beef, veal, pork, poultry, fish, eggs, and milk. The pet food industry also benefits by having access to a vast array of nutrient-rich and flavorful ingredients for rations that maintain healthy companion animals.

2005 Production and Exports of U.S. Rendered Products

PRODUCT	PRODUCTION *in 1000 metric tons*	EXPORTS *in 1000 metric tons*
Inedible Tallow	2,208	650
Meat Meal & Tankage	2,704	194
Edible Tallow	790	139
Yellow Grease	606	289
Feather Meal	393	42

Source: US Dept. of Commerce, M20K Series, US Bureau of Census

The economic impact of the rendering industry is significant as the manufacture and trade in rendered products is an important component of the agricultural economy of the United States. During 2005, the production value of US rendered products was estimated at approximately $2.7 billion. The total production volume of rendered products in 2005 was 8,067 thousand metric tons with exports totaling 1,427 thousand metric tons.

These valuable ingredients are in demand because they are high quality, uniform, stable, affordable, and nutritionally dense. Because North American renderers process at optimum temperatures over a prescribed length of time and because they use strict quality control procedures such as ISO 9000, good manufacturing practices (GMPs), and embrace the principles of hazard analysis critical control points (HACCP), they produce protein meals and fats that are safe and reliable feed ingredients for animals.

Animal protein meals are excellent sources of calcium, phosphorus, protein, and essential amino acids. Animal fats added to feed rations provide needed energy and improve palatability. Animal fats can also be used as a biofuel or as a raw material to be used to produce biodiesel.

To render: "to reduce, convert, or melt down (fat) by heating."

— from Old French *rendre*, "to give back."

Animal byproducts that would otherwise have been discarded have for centuries been rendered into fat which is an essential ingredient in the manufacture of soap, candles, glycerin, and industrial fatty acids. More recently animal protein meals have been produced as feed supplements for companion, meat producing animals, poultry, fish and fat is used as a biofuel.

And indeed rendering does give back. Animal byproducts that would otherwise have been discarded have for centuries been rendered into fat which is an essential ingredient in the manufacture of soap, candles, glycerin, and industrial fatty acids. More recently animal protein meals have been produced as feed supplements for companion, meat-producing animals, poultry, fish and fat is used as a biofuel.

The Producers and the Process

Renderers operate about 302 rendering plants in North America. Some of these are associated with a slaughtering facility (packer/renderers) and process only the facility's by-products. The others are independent facilities that gather raw material from other processors, supermarkets, butcher shops and restaurants.

Rendering is a cooking and drying process that yields fat of varying grades, both edible and inedible, and animal and poultry protein meals. At one time fat was separated from raw material by boiling the raw material with water, a process known as wet rendering. Now it is done by dry rendering, a process that releases the fat by dehydrating raw material in a batch or continuous cooker. This process eliminates the direct physical contact of added water and live steam with raw materials.

In batch cooking, the horizontal vessel is filled with raw material and sealed. The material is processed under controlled conditions at atmospheric pressure depending on the raw material, the cooked material is discharged, and the cycle is repeated. With continuous cooking, the raw material is fed semi-continuously to the cooker, and the cooked material is discharged at a constant rate. A continuous rendering system normally consists of a large single cooking unit, whereas the batch system consists of a few to many, smaller cooking units. A continuous system usually has a higher capacity than a batch system, which allows for more efficient processing of the raw material by processing more material in less time. When the raw material is processed, it is first mechanically sized and then cooked. As the material cooks, it releases moisture and fat.

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The discharge from the cookers is either passed across a vibrating screen or is conveyed over a perforated screen (drain screw) to allow the free-run fat to drain. This process separates the greasy cooked product (tankage—35% fat content) from the free fat. These greasy protein solids (4 to 6% moisture) are processed through a screw press to reduce the residual fat in the pressed protein to approximately 10 to 12% dry rendered tankage, called cracklings. Cracklings are sometimes sold as a commodity and priced on their protein content. Otherwise, cracklings are screened and ground with a hammermill to produce meat meal (less than 4% phosphorus), or meat and bone meal (more than 4% phosphorus).

1. Product Quality

Product quality begins with the raw material, but timeliness is also essential.

Quality of the finished products also depends on conveying, pumping, and storage conditions.

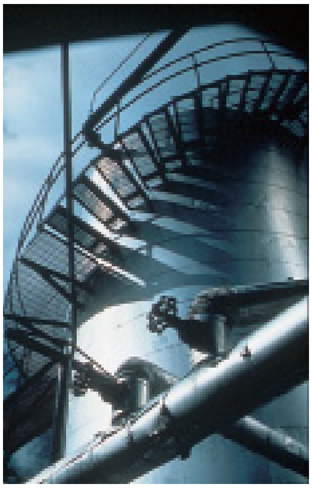
Product quality begins with the raw material, but timeliness is also essential. Subjecting the raw material to heat as quickly as possible will prevent enzymes and bacteria, that occur naturally in all raw animal byproducts, from degrading the protein and fat. The raw material is cooked at a predetermined and continuously monitored and maintained temperature, at atmospheric pressure. To ensure that the raw material throughout the vessel cooks uniformly (which, incidentally, increases production rate and decreases energy costs), it is chopped into pieces of 2.5 cm (1 inch) in diameter or smaller. The same heat that removes moisture and extracts fat also inactivates pathogenic organisms in the animal's tissues.

Quality of the finished products also depends on conveying, pumping, and storage conditions. Feed grade animal fat or more properly, "fat product, feed grade," as officially defined by the Association of American Feed Control Officials (2006) is "any fat product which does not meet the definitions for animal fat, vegetable fat or oil, hydrolyzed fat, or fat ester. It must be sold on its individual specifications which will include the minimum percentage of total fatty acids, the maximum percentage of unsaponifiable matter, the maximum percentage of insoluble impurities, the maximum percentage of free fatty acids, and moisture. The specifications must be guaranteed on the label. If an antioxidant(s) is used, the common name(s) must be indicated followed by the words "used as a preservative." It must be sold on its individual specifications, including:

Total fatty acids	minimum %
Unsaponifiable matter	maximum %
Insoluble Impurities	maximum %
Free fatty acids	maximum %
Moisture	maximum %

The US Food and Drug Administration (FDA) has regulatory authority over the production of rendered products. Section 201 of the Food, Drug, and Cosmetics Act defines food as "articles used for food or drink for man or other animals." This section of the act categorizes animal feed with food for humans.

Renderers typically incorporate good manufacturing practices (GMPs), hazard analysis and critical control point (HACCP), or ISO 9000 in their processes. These procedures ensure that their rendered products will be produced in a sanitary and wholesome fashion.



Fats must be sold on their individual specifications, including the minimum percentage of total fatty acids, the maximum percentage of insoluble impurities, the maximum percentage of free fatty acids, and the amount of moisture. The specifications must be guaranteed on the label. If an antioxidant(s) is used, the common name(s) must be indicated followed by the words "used as a preservative."

Storage

As with any dry feed ingredient, animal and poultry meals can be kept for long periods if stored in the proper environment. The rendering process kills all bacteria from the product as it leaves the cookers; however like other feed ingredients, the meals can be recontaminated through various environmental sources during storage, handling, and distribution. Since animal proteins provide a food source that could enhance bacterial growth, extra care must be taken to prevent bacterial and water contamination when storing and handling meals. To increase the shelf-life of the meals, antioxidants can be added, either during cooking or during the blending of various meals.

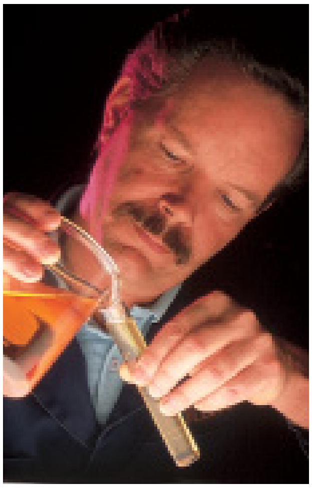
Fats should be stored and handled in steel or iron tanks and pipes, and any contact with brass or copper avoided. Even short exposure to brass or copper accelerates oxidation, leading to rancidity. Moderate heat will not damage dry, clean fat; but moderate heat in the presence of excess moisture and insolubles increases the free fatty acids and instability of the fat, resulting in a higher probability of rancidity. When fats are handled properly and stabilized with the right amount and type of antioxidant, they can be stored for long periods. Every effort should be made to avoid admitting air to the fat, specifically: Seals on the suction side of truck-unloading pumps should be tight; and, fat should be brought into tanks through internal down-pipes with tips submerged or floating.

Fat must be liquid to be pumpable, however care is needed as excess heat accelerates all deterioration processes. Storing fats at temperatures slightly above the melting point will maintain the quality of the final product. Then, immediately before application, the fats should be heated to improve mixing and absorption in feeds.

Animal feeds contain natural oils and added animal fats and other lipid-like compounds, such as vitamins A, D, E, and K and flavorings. All fats and oils have the potential to deteriorate (oxidize). The appropriate use of antioxidants prevents deterioration. Environment factors—more than 0.5% moisture, excessive temperature, the presence of light, contact with oxygen and enzymes—all can influence the degree and rate of oxidation.

Antioxidants react with free radicals to form molecules that are less reactive, and therefore stop free radicals from catalyzing the propagation of additional radicals. Of the many natural and synthetic antioxidants available, those commonly used for fat are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), mixed tocopherols, ethoxyquin, and citric acid. The efficacy of the antioxidant depends on the fat. Laws and regulations also control antioxidant use. Many countries limit maximum levels; tertiary butylhydroquinone (TBHQ), for instance, is widely used in the United States but is not authorized for use in the European Union.

2. Quality Control



At the same time as heat removes moisture and extracts fat, it inactivates pathogenic organisms in the animal's tissues.

Rendered fats and animal and poultry protein meals are subjected to various laboratory tests to ensure that the product meets specifications for its type.

Tests for fats:

- **Boehmer number** refers to a test to find out whether tallow is mixed in with lard. A number is less than 73 indicates that contamination has occurred.
- **Chick edema** is the name of a test conducted by gas chromatography used to detect chemicals found in herbicides that cause abnormal accumulation of body fluid in connective tissue (edema) in chickens.
- **Color** is quantified by comparing a sample of filtered liquid fat to the Fat Analysis Committee (FAC) standard and assigning it a number from 1 (lightest) to 45 (darkest). Other tests are also commonly used.
- **R&B** (refined and bleached) color defines tallow grade. For example, the specification for extra fancy tallow is usually 1 red, but is sometimes specified at 0.5 red.
- **Fatty acid profile** is the relative amounts of the 16 possible fatty acids as determined by gas chromatography.
- **Free fatty acids (FFA)**, the amount of fatty acids split from the triglyceride or fat molecule and dissolved in the fat, are a measure of the hydrolysis that has taken place within the fat molecule. Time, temperature, and the presence of moisture, bacteria, and enzymes influence the hydrolysis of fat into free fatty acids and glycerol.
- **Insoluble Impurities** is defined as the small amount of sediment that is included as a routine analysis for all fats and oils including tallow and is the "I" portion of the M**I**U analysis. Trade of tallow (less than 0.15% impurities) and derivatives made from this tallow should not be restricted regardless of a country's bovine spongiform encephalopathy (BSE) status.
- **Iodine value (IV)** is a measure of the chemical unsaturation of the fat. It is expressed as the number of grams of iodine absorbed by 100 g of fat sample.
- **Moisture, impurities, unsaponifiables (MIU)** should not exceed 1 to 2%, depending on how the fat is to be used. Moisture in fat arises from slight emulsification during processing and is determined by distillation with toluene or by heating; it should be 0.5 to 1%. Unsaponifiables are any material that will not saponify (form soap) when mixed with a caustic, including sterols, pigments, and hydrocarbons. They are soluble in ordinary fat solvents, however, because the animal cannot digest them, they lower the energy value of the fat. These particles are inherent in all fats, both animal and vegetable, and may arise from contamination.
- **Peroxide value (PV)** (also referred to as initial peroxide) is a measure of the amount of oxidation that has occurred in the fat.

Feeding trials of extracted fats and oils to animals have been reported since the 1890s, but fats and oils in quantity did not become available at affordable prices until the 1940s.

Specifications for Tallows & Greases

SPECIFICATIONS GRADE	Titre Min °C	FFA max	FAC max	R&B max	MIU
Edible Tallow	41.0	0.75	3.0	none	*
Lard	38.0	0.50	***	none	*
Top White Tallow	41.0	2.00	5.0	0.5	1
All Beef Packer Tallow	42.0	2.00	none	0.5	1
Extra Fancy Tallow	41.0	3.00	5.0	none	1
Fancy Tallow	40.5	4.00	7.0	none	1
Bleachable Fancy Tallow	40.5	4.00	none	1.5	1
Prime Tallow	40.5	6.00	13-11B	none	1
Special Tallow	40.0	10.00	21.0	none	1
No 2 Tallow	40.0	35.00	none	none	2
A Tallow	39.0	15.00	39.2	none	2
Choice White Grease	36.0	4.00	13-11B	none	1
Yellow Grease	***	****	39.0	none	2

* moisture maximum 0.20%, insoluble impurities maximum 0.05%
** Lovibond Color 5¼ cell–max 1.5 red. Lard peroxide value 4.0 ME/K Max.
*** Titer minimum and FFA maximum, when required, to be negotiated between buyer and seller on a contract-by-contract basis.
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Source: American Fats & Oils Association

- **Pesticide residue** must not exceed defined levels for certain chemicals that are toxic to animals—0.5 ppm for DDT, DDD, and DDE; 0.3 ppm for dieldrin; 2.0 ppm for PCB.
- **pH** is determined on a scale of 0 to 14: 7 is neutral, below 7 is acid, above 7 is alkaline.
- **Polyethylene (PE)** is a foreign material in tallow, which finds its way into the rendering plant as meat wrappers mixed in with raw material.
- **Rate of filtration** is an analytical method in which a given volume of liquid fat sample will filter in a specified time under standard conditions. Filtration is slowed by the presence of fine particles and glue substances; the rate of filtration indicates whether a batch of fat will give processing difficulties.
- **Saponification value (SV)** is an estimate of the mean molecular weight of the constituent fatty acids in a fat sample. It is defined as the number of milligrams of potassium hydroxide required to saponify 1 g of fat. The higher the SV, the lower the mean chain length of the triglycerides.
- **Titer** is the solidification point of the fatty acids, an important characteristic in fats used to produce soap or fatty acids. Trade practice is to designate animal fats with titers of 40°C and up as tallow, and those below 40°C as grease.
- **Total fatty acids (TFA)**—both the free fatty acids and those combined with glycerol (intact glycerides)—should exceed 90%. Fat is composed of approximately

The energy value of 50% protein meat and bone meal is approximately 2500 kcal/kg.

The most efficiently used protein supplement is blood meal; it guarantees 85% crude protein.

Average Nutrient Composition of Animal Protein Feeds

	MEAT MEAL	MEAT & BONE MEAL	HYDRO-LYZED FEATHER MEAL	POULTRY BY-PRODUCT MEAL	BLOOD MEAL
Crude Protein (%)	55	50	80	58	85
Crude Fat (%)	10	10	6	12	1
Crude Fiber (%)	2	3	3	2.1	1
Crude Ash (%)	15	28.8	2.8	18	4.5
Moisture (%)	7.5	7.5	7.5	6.5	9.5
Metabolizable Energy (kcal/kg)	2776	2444	3240	3300	3420
TDN (g/kg)	78	69	82	88	94
Calcium (%)	8.5	10.1	0.33	3	0.3
Phosphorus (%)	3.5	5.0	0.55	1.7	0.25
Methionine (%)	0.8	0.7	0.6	1.2	0.6
Methionine & Cysteine (%)	1.15	1.05	3.6	2.2	2.0
Lysine (%)	3.2	2.75	2.0	2.7	7.0
Tryptophan (%)	0.5	0.5	0.5	0.5	1.1
Choline (mg/kg)	2100	2000	1090	5940	750

* Average values of US commercial samples decreased by ½ standard deviation according to actual variation

Source: National Renderers Association

90% fatty acids and 10% glycerol. The calorie content for glycerol is about 4.32 calories per gram compared with 9.4 for fatty acids. Since fatty acids contain more than twice the energy of glycerol and some other fatty substances, the TFA content of fat indicates energy content.

Tests of animal and poultry protein meals:

- **Ash** is the percentage of the residue of mineral matter remaining after incineration. The ash content varies with the raw material, reflecting the ratio of bone to soft offal processed.
- **Calcium to phosphorus ratio** in meat and bone meal cannot exceed 2.2 to 1 with the actual content being approximately 9 to 10% calcium and 4.0 to 4.5% phosphorus.
- **Digestibility** is the percentage of feed stuff taken into the digestive tract that is absorbed into the body. Meat and bone meal is 85% digestible or better using .2% pepsin.
- **Fat content** of animal and poultry protein meals is the residual fat left after centrifuging and pressing, usually 8 to 11% for meat meals and 10 to 14% for poultry meals.

By the time the product leaves the cookers, the rendering process has killed all bacteria.

- **Fiber** is a relatively indigestible carbohydrate of little value to animals other than ruminants. Fiber content of meat and bone meal is normally less than 2% (soybean meal contains 5 to 6%).
- **Microscopic analysis** reveals impurities such as sand or glass and metal particles.
- **Moisture content** in meals is the residual water after the raw material has been cooked; it typically varies between 4 and 6% with a maximum of 10%. A lower percentage indicates overcooking.
- **Pesticide residues—**tolerance levels for the residual fat are the same as for free fats (0.5 ppm for DDT, DDD, DDE; 0.3 ppm for dieldrin; 2.0 ppm for PCB).
- **Protein content** varies with the product: 45 to 55% for meat meals with 50% being the standard; 80 to 90% for blood meal; 58 to 70% for poultry byproduct meal; 80 to 90% for feather meal; 57 to 77% for fish meal.
- **Salmonella** contamination can be reduced by adhering to good manufacturing practices, namely preventing traffic of workers and equipment from the raw-material–handling area into the finished goods area and controlling excessive dust and moisture in finished material, handling equipment, and storage area. An insect, bird, and rodent control program is essential.

3. Animal Nutrition

Livestock, poultry, and fish require approximately the same nutrients as human beings—protein, carbohydrates, fat, minerals, vitamins, etc. Animals must be well nourished if they are to be healthy and produce high quality meat, milk, eggs, and fish.

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Animal Fats

The following categories of animal fats are recognized:

- **Choice white grease** – A specific grade of mostly pork fat defined by hardness, color, fatty acid content, moisture, insolubles, unsaponifiables, and free fatty acids.
- **Edible tallow** – Exclusively beef, this product is rendered from fat trimmings and bones taken from further processing at a slaughterhouse. The product is of light color and low moisture, insolubles, unsaponifiables, and free fatty acids. The tallow may be further refined, polished, and deodorized to become a cooking fat. The pet food industry generally uses the crude product not shipped under seal, often referred to as technical tallow.
- **Edible** – Fats and proteins produced for human consumption which are under the inspection and processing standards established by the US Department of Agriculture, Food and Safety Inspection Service (USDA/FSIS).
- **Fat products** – Tallow and grease.
- **Feed grade animal fat** – Also known as "Fat product, feed grade" is any fat product which does not meet the definitions for animal fat, vegetable fat or oil, hydrolyzed fat or fat ester. It must be sold on its specifications which will include the minimum percentage of total fatty acids, the maximum percentage of unsaponifiable matter, the maximum percentage of insoluble impurities, the maximum percentage of free fatty acids and moisture.
- **Inedible** – Fats and proteins produced for animal, poultry, and fish consumption or for other non-edible uses.
- **Lard** – Edible grease, the process and parameters of which are the same as for edible beef tallow, but with pork as the raw material.
- **Poultry fat** – Animal fat produced from poultry.
- **Tallow** – Primarily from beef fat, defined by hardness, moisture, insolubles, unsaponifiables, free fatty acids, fatty acid content, and color with a titer of 40.0°C or higher.
- **Yellow grease** – This material is usually made up of restaurant greases (fats and oils from cooking). Another source could be from rendering plants producing lower quality tallow, fats, and greases.

Fats contain approximately 2.25 times the energy content of cereals and soybean meal. Moreover studies indicate that fat has a synergistic response in swine feeds and can be worth as much as 3.8 times the value of corn on a net energy basis.

Uses of Animal Fats

Of the many uses for rendered fats and greases, in North America the largest market is as a supplement in animal feeds. Occasional feeding trials of extracted fats and oils to animals have been reported since the 1890s, but fats and oils in quantity did not become available at affordable prices until the 1940s.

The practice of feeding fats grew rapidly in the 1970s and 1980s. Adding fat to diets improves the profitability of livestock and poultry production by lowering the cost of production. Specifically, added fat offers the following advantages:

- reduces dust
- provides essential fatty acids
- enhances food palatability
- increases energy density of rations and feed efficiency
- prevents constipation
- counteracts heat stress
- serves as an efficient energy source
- improves absorption of fatsoluble vitamins
- increases egg weight
- improves persistence of lactation and milk yield
- improves piglet survival and litter size
- is a source of energy
- is a carrier of fat-soluble vitamins.
- usually guarantees low feed conversion rates.
- can affect shrimp body cholesterol level, hence molting and growth rates. It also affects body fatty acid profiles and fatty acid profiles in the hepatopancreas.

Animals convert carbohydrates and fats to heat energy to maintain body temperature and energy for growth, strength, and vital bodily functions. Simple carbohydrates, such as starches and sugars are highly nutritious and easily digested. Complex carbohydrates, like those from the fiber of plants, are much less digestible and are important only to cattle, sheep, goats, and other ruminants. Traditional small grains for ruminants usually contain from 1 to 3% fat, 8% minerals, 18% protein, and 71% carbohydrates. Fats contain approximately 2.25 times the energy content of cereals and soybean meal. Moreover studies indicate that fat has a synergistic response in swine feeds and can be worth as much as 3.8 times the value of corn on a net energy basis.

Dietary fat also contributes an extra caloric effect by interacting with other dietary components to increase their absorption that, in turn, increases the metabolizable energy of the diet. Furthermore, added fat increases utilization of the metabolizable energy by reducing the heat increment, which increases the net energy of the diet.

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Thus energy and nutrients are much more concentrated in a diet high in fats than one high in carbohydrates. This concentration permits greater flexibility in formulating cost-effective feeds. Such flexibility is especially important in regions of the world where grain is considered too valuable to be used in animal feed; areas where the feed manufacturer must rely on less expensive, low-energy grain byproducts.

Other improvements include the lubricating value of fats, reduction of dust, reduction of particle separation, and improved palatability of feeds for all species. Adding fat to feeds prevents particle settling as it reduces dust in equipment.

Dairy cows may lose 1 to 1.5 kg (2 to 3 lb) body weight per day during early lactation. If weight loss is excessive or if body fat stores are depleted, milk production, health, and reproduction will be compromised. Consequently, maximizing energy intake during early lactation becomes critical. Supplemental animal fat can contribute as much as 3.5% of dry matter. A rule of thumb is to feed an amount of fat equivalent to that secreted in the milk. For the first 6 weeks of lactation, supplemental fat should be limited to 0.25 to 0.5 kg (0.55 to 1.1 lb) per cow per day. Animal fat can be mixed in rations as long as milk yield or body conditions respond, perhaps 20 to 30 weeks of lactation.

The major use of fat in **beef cattle** diets is to increase average daily weight gain and efficiency of feed utilization. For example, supplementing diets of flaked milo or dry

Recycling Animal Byproducts

These photographs illustrate the recycling of animal byproducts into millions of dollars worth of new products.

rolled corn with 4% fat increased daily gain and feed efficiency, and improved the carcass characteristics, as did adding 4 to 8% yellow grease to barley-based diets.

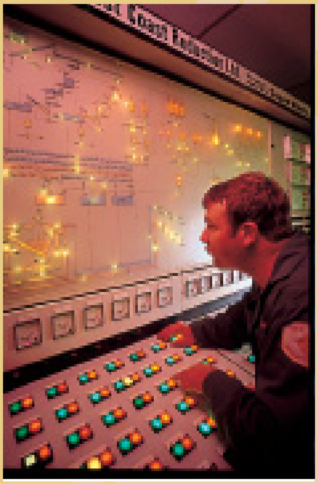
Today, producers are successfully feeding 2 to 4% supplemental fat in ruminant diets. This variation depends on the level of residual fat content in the principal feed grains used in the ration. Tallow (which produces a much higher response than grease or vegetable oil), grease, and animal–vegetable fat blends are economical sources of fat for this purpose.

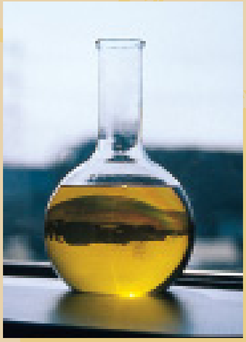
Likewise, with lactating **sows**, supplementary fat increases energy density, reduces voluntary daily feed intake (thereby lowering the feed cost per sow), increases metabolizable energy intake, reduces weight loss, and increases weanling weights. Feeding high levels of fat to sows before farrowing and during lactation has been shown to increase lipid content of both colostrum and milk by about 2%; adding 9% fat to the lactation diet has improved pig weanling weights by 8%. Thus increase in fat content is associated with increased piglet survival.

Chickens and **turkeys** also benefit from increased dietary energy and nutrient density. Poultry eat primarily to satisfy their energy needs. When animals have met their energy needs, they tend to stop eating. If the amount eaten at that time is inadequate in protein or other nutrients, then they suffer from a deficiency of those nutrients and the increased energy is of little or no value. The use of fats in broiler rations increases palatability, provides essential fatty acids, reduces losses from dust, and increases egg weight.

Traditionally **ducks** were raised for egg production, but now they are being raised primarily for meat. Ducks grow faster than chickens, for example an 8-week-old duck weighs about 3 kg (6.6 lb) to the chicken's 2 kg (4.5 lb), while their daily food consumption is only somewhat greater. Ducks' energy requirements are high enough for them to benefit from a diet supplemented with 20 to 25% fat.

Formulated **aquaculture** feeds are often high in lipids, the bulk of which is generally provided by fish oil. Because of its cost, foreseeable long-term supply problems, and more recently, concerns over contaminant levels, it is widely acknowledged that fish oil should be used more sparingly in aquaculture feeds.





After slaughter, the non-edible parts of the animals (some 60%) are sent to state-of-the-art rendering plants throughout the United States. At the rendering plant the nonfood parts are made into tallow and meal. The tallow and meal are stored in specially adapted facilities to await shipment to buyers around the world who will use them as ingredients in a vast array of new products – animal feed (including petfood), fabric softeners, lubricants and plasticizers, candles, soaps, crayons, waxes, cleaners, personal care products, buffing compounds, and biofuel.

Rendered animal fats, because of their low costs and wide availability, could be an interesting alternative for part of the fish oil in fish feeds.

The cost of aquafeed could be reduced by about US$3/ton for every percentage point (1%) of fish oil replaced by rendered fats.

Fish oil availability is increasingly problematic since the demand has grown considerably with the expansion of the aquaculture industry. Various projections suggest that within a decade, the demand for fish oil will be well above the available supply. Along with this increase in demand, the price of fish oil has also risen considerably. The market price for fish oil has varied between US$0.20 and $0.80/kg over the past decade. Prices in recent years have consistently remained high.

Rendered animal fats, because of their low costs and wide availability, could be an interesting alternative for part of the fish oil in fish feeds. Opposite to fish oil prices, the price of inedible animal fats has decreased in the last 10 years by 40-50% to a current price of about US$0.30/kg for good quality choice white grease and tallow. Substantial savings could be made immediately by substituting some of the fish oil in feed formulae with these more economical lipid sources. The cost of aquafeed could be reduced by about US$3/ton for every percentage point (1%) of fish oil replaced by rendered fats

For all livestock and poultry, the most significant response to added fat will likely occur in summer when heat stress reduces voluntary feed intake. Digestion and metabolism of feed nutrients produces heat. If an animal is heat stressed, it eats less to reduce the heat load and stress of dissipating heat. Many species of animals have been shown to generate less heat during digestion and metabolism of fat than of proteins and carbohydrates. Therefore, feeding fat during heat stress lessens the heat load as it increases the energy density of the diet during periods when feed intake is depressed. Reducing heat stress with added fat may tend to reduce livestock death loss associated with hot weather.

Fats are required in the diets of pets for absorption of the fat-soluble vitamins A, D, E, and K, and they enhance the palatability of the food. Fats also serve as an excellent source of essential fatty acids and of dietary energy, yielding approximately 2.25 times more energy than either soluble carbohydrates or proteins.

Meat and bone meal is a staple ingredient in poultry feed. The energy value of 50% protein meat and bone meal is approximately 2,500 kcal/kg. Meat and bone meal is rich in protein and undegradable protein.

Meat and bone meal is a high protein feed ingredient for carnivorous and omnivorous aquatic animals and should be mainly considered for its cost advantage over fish meal (FM).

Animal Protein Meals

Proteins, composed of 20 different amino acids, are liberated during digestion. These amino acids are essential to formation, maintenance, and repair of muscles, tissue, and organs. The roughage feeds (plants including pasture grasses, wheat, corn, oats, rye, barley, and sorghum) have limited protein, whereas, meat and bone meal, feather meal, blood meal, poultry meal, poultry byproduct meal, and fish meal are high in protein content.

Variable raw materials (dead stock, offal, meat trimmings, bones) contribute to the great diversity of commercial meat and bone meals, and influence protein quantity and quality. High bone content reduces crude protein as a percentage of the whole, but increases calcium and phosphorus levels.

Meat and bone meal is produced from mammalian tissues including bone but excluding extraneous blood, hair, hoof, horn, as may occur, and stomach and rumen contents. It contains 45 to 54% crude protein, 11% fat, and more than 4% phosphorus.

As crude protein increases in the meals, amino acid content also increases. Meat and bone meal and meat meal tend to vary in nutrient content both among samples produced at the same rendering plant and among different processing plants. Processor-to-processor variation suggests that feed formulators should modify nutrient contents based on the origin of meat and bone meal and meat meal.

Meat and bone meal is a staple ingredient in poultry feed. The energy value of 50% protein meat and bone meal is approximately 2,500 kcal/kg. Meat and bone meal is rich in protein and undegradable protein. It, like blood meal, is an excellent source of lysine.

Meat and bone meal and meat meal are the predominant rendered animal proteins fed to swine. Both are excellent sources of available phosphorus and calcium and are moderate sources of digestible amino acids and digestible energy.

Meat and bone meal (MBM) is a high protein feed ingredient for carnivorous and omnivorous aquatic animals and should be mainly considered for its cost advantage over fish meal (FM) as its nutritive value is slightly lower than fishmeal. The maximum FM protein replacement rate by MBM is 60% for L. vannamei and 80% for P. monodon. Under the limited water exchange culturing system, the FM protein replacement rate could be increased to 100% by poultry byproduct meal and MBM. Decisions on ingredients selection and their inclusion rates when formulating aqua feeds should largely be based on an accurate nutrients composition, digestibility, palatability, and the risk of anti-nutritional factors.

Feather meal can be used to increase the nutrient and energy density of poultry feeds, improving feed efficiency and reducing the amount of feed that must be mixed, handled, and consumed for each pound of poultry meat or dozen eggs produced.

Meat meal is produced from the same mammalian tissues as meat and bone meal, except that it contains less bone. The product contains 52 to 60% crude protein, 11% fat, and less than 4% phosphorus.

Hydrolysis of feathers under heat and pressure transforms the protein in feathers to an easily digested (68 to 93% depending on species) feed supplement. Pure hydrolyzed **feather meal** normally contains 80% crude protein and 3 to 5% fat, but processing methods affect the quality of the meal. Feeding feather meal can be made more economical by adding 12.5% to 25% blood meal because blood meal and feather meal combine synergistically

Feather meal can be used to increase the nutrient and energy density of poultry feeds, improving feed efficiency and reducing the amount of feed that must be mixed, handled, and consumed for each pound of poultry meat or dozen eggs produced. Unsupplemented poultry rations based primarily on corn and soybean meal are almost equally deficient in the amino acids, methionine, and cysteine. Soybean meal could be replaced by feather meal up to a level of 6% in the starting diet and 4% in the finishing diet without adding additional amino acids.

Feather meal has also been found to be a useful feed ingredient for turkeys. One diet recommends using blood meal at 2%, feather meal at 2 to 4%, and meat and bone meal at 7 to 8% of rations for growing turkeys.

The most efficiently used protein supplement is **blood meal**. Produced from clean, fresh animal blood, exclusive of extraneous material such as hair, stomach contents, and urine, it guarantees 85% crude protein. Spray-dried and ring-dried whole blood meals are vastly superior to the vat-dried blood meals used in the past. Vat-dried blood meals have very low nutritional value because the required heat damages the protein (especially lysine). Dried blood meals are relatively uniform in digestibility and nutrient content: most contain 87 to 89% crude protein, about 40% more supplemental protein than soybean meal. Only 20% of the blood meal is degraded in the rumen allowing it to be available in the small intestine, whereas soybean meal protein is about 70% degraded. Blood meal, like meat and bone meal, is deficient in methionine, but contains about 8% lysine, 1% tryptophan, and 4% threonine. Blood meal can be added at the rate of 0.2 to 0.5 kg (0.5 to 1 lb) per cow per day.

Spray-dried porcine plasma contains non-nutritive factors that stimulate feed intake in the 14- to 21-day-old weaned pig. Used at an inclusion rate of 5 to 7.5% this product has essentially eliminated the post-weaning lag in performance common to weaned pigs. But the response is short-term; by 7 days after weaning, pigs are adapted to dry feed intake and the response to spray-dried plasma diminishes.

Proteins, composed of 20 different amino acids, are liberated during digestion. These amino acids are essential to formation, maintenance, and repair of muscles, tissue, and organs.

Spray- and ring-dried blood meals are widely used in salmonid feeds due to their very high digestibility and consistent quality. Good performance of fish have been observed for fish fed diets containing approximately 8 to 20% blood meal.

Pure hydrolyzed feathermeal normally contains 90% crude protein (guaranteed 80%) and 3 to 5% fat.

Poultry byproduct meal consists of ground, rendered, clean parts of the carcass of slaughtered poultry, such as necks, feet, and viscera, exclusive of feathers. Feed grade meal typically consists of 58 to 62% protein, 12 to 15% fat, and 18 to 23% ash. It is a good source of lysine and methionine. Because of its availability, nutrient profile, and price structure, poultry byproduct meal is being used more and more as a replacement for fishmeal. It compromises as much as 5 to 10% of broiler and turkey rations. When poultry byproduct meal is added to broiler rations, it provides essential energy and nutrients.

Poultry byproduct meal is also a very important ingredient in pet foods, typically supplying at least 64% protein, a maximum of 14 to 15% ash, and 12 to 15% fat.

Poultry byproduct meal is a high protein animal source of dietary ingredients for carnivorous and omnivorous aquatic animals. Recent research indicates that poultry byproduct meal resembles fish meal in nutritive value (composition, digestibility, FI, FCR and body composition of fish and shrimp) and could replace most of the fish meal (up to 80%) in shrimp and several economically important fish diets without causing a reduction in weight gain.

4. Non-Food & Feed Products

Biodiesel is an alternative fuel that burns cleaner, is renewable and can be refined from domestic feedstock, including animal fats, recovered cooking oils and vegetable oils.

Animal fats and oils can be used as a biofuel in industrial boilers or to fuel furnaces.

Rendered animal fat has been used to provide light (oil lamps and candles) and to make soap for more than 2,000 years. People still use rendered fat to make candles and soap, but this does not imply lack of progress. Today, the 5- to 10-day soap-making process has shrunk to an 8- to 16-hour process; air and lighter products can be incorporated into the soap to make it float; it can be multicolored or translucent; deodorant and antibacterial agents can be incorporated; the soap can be liquid or solid; it can foam or not; it can contain abrasives such as pumice or not.

Biodiesel is an alternative fuel that burns cleaner, is renewable and can be refined from domestic feedstock, including animal fats, recovered cooking oils and vegetable oils. Growth in the biodiesel industry creates new markets for domestic Ag commodities as well as rendered animal byproducts and restaurant greases, making biodiesel refined from animal fats and yellow grease, a truly "recycled" domestically produced renewable fuel.

Because of their chemical composition, fats release concentrated amounts of energy when burned. This energy can be used as a **biofuel** in industrial boilers or to fuel furnaces. Most fats provide comparable amounts of heat to common fuel oils.

An important byproduct of alkaline soap manufacturing and biodiesel production is glycerin, first identified in 1779. Among other things, it is used in adhesives, antifreeze, cleaners and polishes, corrosion-prevention coatings, cosmetics, dental creams, explosives, food and beverages, leather tanning and finishing, metal processing, paper, pharmaceuticals, photography, resins, textiles, and tobacco. By the end of the 1980s, 1.5 billion lb (680 thousand metric tons) of refined glycerin was being produced globally.

Alkyd resins provide versatile, low-cost paints and varnishes for purposes ranging from house painting to portrait painting. Leather processors use fats and oils as detergents and as additives (fat liquors) to soften leather. Textile processors use oils and fats for scouring, dyeing, and softening. Topical (applied to the skin) pharmaceuticals rely on fats and oils to keep the therapeutic agent on the skin long enough to deliver the desired dose of medication. Cosmetics—hand and body lotions and creams, hair conditioner, hair dressing, powder, makeup, sunscreen, bath products—incorporate lipids and triglycerides found in fats and oils.

5. Environmental Aspects

Feed is abrasive and dusty and can cause excessive wear on equipment. Adding fat reduces the abrasiveness, thereby increasing the life of feed mixing and handling equipment. Similarly, adding fat reduces the power requirement for pelleting feeds and increases the life of the pelleting dies. Moreover, 1 or 2% of feed is no longer lost to dust.

The US rendering industry recycles more than 26 million metric tons of animal byproducts annually because only about 50% of a cow, 60% of a pig, 72% of a chicken, and 78% of a turkey actually end up in the meat case. In more concrete terms, a 454 kg (1000-lb) steer consists of about 182 kg (400 lb) of inedible material. Without the rendering industry, byproducts from meat and poultry processing would fill up the landfills. But volume is not the only problem. These inedible parts are highly perishable, so the volume must be disposed of before it decomposes (malodorously) and contaminates our soil and water with disease-causing microorganisms and vermin. The rendering industry does just that by converting this material into value-added usable commodities—tallow, greases, and animal proteins.

Wastewater from a rendering plant derives from 3 sources: condensate from the cooking vapors, wash water to clean the plant and the collection trucks, and discharge from the wet scrubbing system. Unlike petroleum oil, animal fat is biodegradable. Treatment removes suspended solids and fat and grease; reduces biochemical oxygen demand, total suspended solids, and fat and grease; and recovers fats and protein solids for processing. It also reduces user charges, if any, for industrial discharges to municipal sewers.

The type and degree of wastewater treatment depends upon whether the effluent from a treatment plant discharges to a city sewer, to a navigable stream, or to land for crop irrigation. Federal and state water pollution control agencies establish water quality standards for discharges to streams. In exchange for user fees, a renderer may discharge wastewater to a city sewer.

Wastewater can be stored in lagoons, or stabilization ponds, 6 to 12 ft (2 to 6 m) deep, during winter in a northern climate, or for evaporation of wastewater in an arid climate. Before discharge, and after filtration, the wastewater passes through a chlorinating chamber to eliminate pathogenic microorganisms such as fecal coliform. To protect aquatic life, the chlorinated water is then dechlorinated before it is discharged to a stream.

Other types of treatment can include activated carbon adsorption to remove organic compounds and precipitate phosphorus removal as well as ion exchange for removal of inorganic dissolved solids. Denitrification uses bacteria in the absence of oxygen (anaerobic digestion) to convert nitrite and nitrate to nitrogen gas.

6. Biosecurity

Energy and nutrients are much more concentrated in a diet high in fats that one high in carbohydrates. This concentration permits greater flexibility in formulating cost-effective feeds.

Other improvements include the lubricating value of fats, reduction of dust, reduction of particle separation, and improved palatability of feeds for all species.

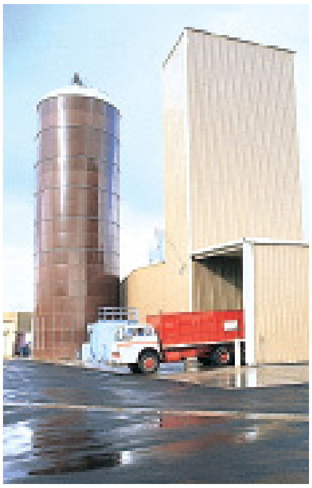
The principles of biosecurity have been introduced into the quality assurance regime of the rendering industry and assure compliance with voluntary guidelines and regulatory standards. The industry members consider that it is in their best long-term interest to follow quality principles and procedures. The industry maintains a working relationship with government to cooperate in the production of safe rendered products.

That is why the North American rendering industry has developed and implemented process control programs that include good manufacturing practices (GMPs) and hazard analysis and critical control points (HACCP) principles. The industry has used these principles and other established programs in an aggressive approach to quality assurance by developing a Rendering Code of Practice. Participating facilities receive accreditation upon passing an audit conducted by the Facility Certification Institute, a third-party auditing firm.

GMPs are preventative practices that minimize product safety hazards by instituting basic controls or conditions favorable for producing a safe product. A "raw material GMP" would be one example and would provide validation that raw materials were not exposed to toxic chemicals or metals prior to processing in a rendering facility. GMPs are necessary for development of a Production Control (PC) program. Rendering companies in the United States have adopted voluntary PC programs as an important component of their biosecurity and food safety programs. PC programs require

- an evaluation of the entire rendering process;
- identification of potential biological, physical, or chemical hazards;
- identification of critical points in the process where the hazard(s) can be controlled; and
- development of procedures to control these processes and ensure the hazard is eliminated or reduced to acceptable levels.

The Food and Drug Administration (FDA) encourages a risk-based approach to identifying and developing limits for hazardous contaminants within feed, and establish process controls with regulatory oversight to ensure compliance. This is consistent with recommendations from the Food and Agriculture Organization (FAO), which called for full traceability and implementation of a code of practice for handling animal by-products and mortalities to ensure safety. The rendering industry Code of Practice fulfills this guidance.



NASA developed HACCP 30 years ago to ensure the safety of equipment in space. HACCP prevents hazards that could cause food-borne illnesses by applying scientific controls at every stage of food production.

Disease Emergence

The rendering industry is continuing to examine the many variables or combinations of factors that can contribute to animal disease emergence (for example, the 1985 occurrence of bovine spongiform encephalopathy in the United Kingdom) and recognizes that newly emergent infectious diseases may result from environmental changes or evolution of existing organisms. The National Renderers Association and the Animal Protein Producers Industry program participants recognize their role in preventing the spread of animal disease by participating in the following:

Surveillance

- Coordinating with the industry, governmental agencies, and allied groups for the early detection, tracking, and evaluation of emerging infections of livestock, poultry, and humans in North America.
- Improving the international network with Canada, Mexico, the European Fat Processors and Renderers Association (EFPRA), and the Australian Renderers Association (ARA), for the anticipation, recognition, control, and prevention of potential problems.
- Strengthening communication and coordinating nationally and internationally to share information relative to new initiatives such as the Rendering Code of Practice, HACCP-like programs and new technologies.

Applied Research

- Integrating the Animal Protein Producers Industry's laboratory findings to expand epidemiologic and prevention effectiveness. Members use *Salmonella* testing to improve processes and products.
- Participate in research by the Fats and Proteins Research Foundation to gain new knowledge on thermal kill times and other conditions to control pathogens
- Encouraging laboratories that serve the rendering industry to develop diagnostic tests, reagents, improved methods, and state-of-the-art technology to meet the changing demands of the industry.

The North American rendering industry has developed and implemented process control programs that include good manufacturing practices (GMPs) and hazard analysis and critical control points (HACCP) principles. The industry has used these principles and other established programs in an aggressive approach to quality assurance by developing a Rendering Code of Practice.

Prevention and Control

- Establishing the mechanisms and partnerships needed to ensure rapid and effective implementation of preventive measures through planning and working with allied groups, coalitions, and regulatory agencies.
- Using diverse communication methods, including publications and press releases when applicable, for more effective delivery of critical messages.
- Coordinating with the industry's technical resources, regulatory agencies of government, academia, and allied groups to assist disease prevention and control initiatives.

Infrastructure

- Strengthening the industry's infrastructure and communication capability to support surveillance, disease-related research, and prevention and control initiatives to ensure prompt implementation of planned strategies. Ensuring the ready availability of professional expertise to help the industry to better understand, monitor, and control potential problems.
- Providing training and continuing education programs to support the established objectives of the industry.

Animal protein meals are loaded into clean bulk containers and shipped to customers around the world.

7. Cost & Economics

Poultry byproduct meal is a high protein animal source of dietary ingredients for carnivorous and omnivorous aquatic animals. Recent research indicates that poultry byproduct meal resembles fish meal in nutritive value (composition, digestibility, FI, FCR and body composition of fish and shrimp) and could replace most of the fish meal (up to 80%) in shrimp and several economically important fish diets without causing a reduction in weight gain.

Animal protein meals are often used in least-cost diet formulations because they are a concentrated source of essential nutrients.

A 100lb (45.4kg) bag of meat and bone meal contains roughly:
50 lb (23 kg) of high quality protein
8 to 9 lb (3.5 to 4 kg) of calcium
4 to 4.5 lb (1.5 to 2 kg) of phosphorus
10 lb (4.5 kg) of fat

Whereas,
a 100lb (45.4kg) bag of dehulled soybean meal contains roughly:
48 lb (22 kg) of protein
and few other critical nutrients

Research & Development

The purpose of the **Fats and Proteins Research Foundation (FPRF)** is to direct and manage a research process that results in an enhanced current usage and the development of new uses for rendered animal products. FPRF has carried out extensive evaluation and assessment studies for the renderers and animal feed industry since 1962.

The scientific process is fundamental to scientific investigation and to the acquisition of new knowledge based upon physical evidence by the scientific community. However, scientific research, like other cooperative endeavors, requires trust to flourish. Cooperation and trust in the rendering industry are reflected by the fact that since establishing the foundation, FPRF has completed over 550 projects. One of the priority areas of FPRF has been to support research on the utilization of animal by- products/co-products processed by the rendering industry, such as blood meal, meat & bone meal, tallow, hydrolyzed hair, and feather meals. During the past 40 years, FPRF research has documented the continued improvement in the rendering industry products as measured by bioavailability, biosecurity, and consistency. Likewise, analytical technology has provided specific nutrient data for formulation purposes. FPRF has also presented an extensive literature base to contest issues such as the presence of biogenic amines in animal proteins and polyethylene in animal fats as being nutritionally detrimental.

Growth in the biodiesel industry creates new markets for domestic agricultural commodities as well as rendered animal byproducts and restaurant greases, making biodiesel refined from animal fats and yellow grease, a truly "recycled" domestically produced renewable fuel.

Other projects have been related to the ecological aspects of the rendering processes. Many past projects were nutritional studies, with others directed at modifications to increase their value and applications.

Biofuel research has been a part of FPRF's research goals since the early 1990s. The rendering industry has experienced significant success in using rendered animal fats as burner fuel. An accumulation of burning characteristics and emission testing by FPRF has allowed for the permitting of substituting animal fats for No. 2 or No. 6 fuel oil or natural gas for the production of steam.

Almost certainly the most remarkable and recent of all the FPRF research achievements have been the official opening of the Animal Co-Products Research and Education Center at Clemson University (ACREC), Clemson, South Carolina. As a result, an initial base of nine specific interdisciplinary alternative use and biosecurity projects were initiated in April 2004. Current research projects at ACREC include chemical analysis of tallow, investigation of growth factors, peptides and pesticides residues in by-product meals, odor remediation, and identification of bacteria isolated from rendering products.

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The National Renderers Association (NRA), headquartered in Alexandria, Virginia, was formed in 1933 as the professional organization of the industry. It represents its members' interests to regulatory and other governmental agencies, promotes the greater use of animal byproducts and fosters the opening and expansion of trade between foreign buyers and North American exporters.

In addition to maintaining a roster of all members, the NRA publishes a newsletter, Renditions; a magazine, Render; and a bulletin, NRA Bulletin, with copies on the NRA web site, renderers.org. Members can use the organization as a technical resource on disease-related issues, as well. The NRA's annual convention provides a forum for renderers from around the world to share experiences and discuss common issues.

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