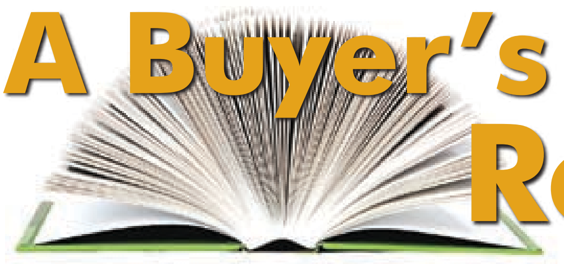

A Buyer's Guide to Rendered Fats

Editor's Note – The following information has been excerpted from the Pocket Information Manual: A Buyer's Guide to Rendered Products *published by the National Renderers Association. The complete manual is available online at www.nationalrenderers.org.*

World production of animal fats is more than 6.8 million tons, with more than half produced in North America. Rendered products are used in five major sectors of today's economy.

The first, and most important, is in livestock, poultry, and aquaculture production, where animal fats and proteins are used in efficient, high-energy rations. This helps to increase production efficiency, thereby making meat, milk, and egg products more affordable. Judicious use in pet foods helps sustain the health and longevity of companion animals.

Industrial use creates a second sector. As many as 3,000 modern industrial products contain lipids and lipid derivatives. Some of the major applications for rendered products include the chemical industry, metallurgy, rubber, and in crop protection agents and fertilizer formulations.

Third is the manufacture of soaps and personal care products. Tallow is still the basic ingredient in making both toilet and laundry soaps. The global market for these products continues to grow.

The food industry, which uses edible tallow, lard, and other edible animal by-products such as defatted meat tissue, gelatin, and blood meal, forms a fourth sector.

Finally, an emerging industrial use is the production of biodiesel from animal fats and recovered cooking oils. Environmental benefits and cost are driving forces behind the growth of using rendered fats and oils in this market.

But before a biodiesel producer can choose a rendered fat as a feedstock, they must first educate themselves on the multiple characteristics of this highly sought-after commodity.

Types of Fats

Industrial Tallow

Animal tissue containing fat is converted to tallow by a process called rendering. Basically, rendering is a procedure by which lipid material is separated from meat tissue and water under the influence of heat and pressure.

There are two principal methods of rendering. In the wet rendering process (old method) the animal tissue is placed in an enclosed pressure vessel (cooker) and superheated steam is injected to provide both heat and agitation. The mixture is cooked at 230 to 250 degrees Fahrenheit (110 to 120 degrees Celsius) for three to six hours. At the end of this period, the mixture settles into three phases: a top fat layer that is drawn off, an intermediate water layer, and a bottom layer consisting primarily of proteinaceous material. This method is no longer in wide usage. Protein and fat quality were more easily compromised during the extended cooking time. In the dry rendering process, the fatty tissue is heated in jacketed containers, mechanical agitation is provided, and the water is evaporated either at atmospheric or at increased pressure.

Today, modern rendering plants feature a continuous rendering process with automated operations and highly sophisticated air and water pollution prevention equipment.

Renderers process a variety of raw materials from various sources, including:

- packing house by-products, such as organ fats, offal, bones, and blood;
- boning house material that consists of bones and meat trimmings;
- meat market trimmings, including adipose and inter-muscular fats, bone, cartilage, and meat trimmings;
- restaurant greases and recovered cooking oils (these are processed and stored separately); and
- fallen animals.

Edible Beef Tallow

U.S. edible beef tallow is made exclusively from the highest quality edible beef fat processed for human consumption and inspected by the U.S. Department of Agriculture's (USDA) Food Safety and Inspection Service. U.S. edible tallow, certified and inspected in food-grade plants, is available deodorized or undeodorized. Deodorized tallow does not alter the taste of foods, whereas undeodorized tallow is often selected to enhance the flavor of foods.

In the United States, regulations specifically restrict meat plants to the processing of only one type of animal, so no mixing of different animal fats occur. These USDA regulations ensure that the product is 100 percent pure beef fat. Certified halal and kosher tallow are also available in the United States.

Lard

Lard is the fat rendered from fresh, clean, sound tissues of swine in good health at the time of slaughter. The composition, characteristics, and consistency of lard vary greatly according to the feeding regime. The higher the level of unsaturated fats in the diets of pigs, the softer (higher iodine value) the fat.

Yellow Grease

This material is usually made from restaurant greases (fats and oils from cooking). Another source could be from rendering plants producing lower quality greases. The specifications for yellow grease are as follows:

- Free fatty acids – 15 percent maximum
- Fat Analysis Committee (FAC) – 39 maximum

• Moisture, unsaponifiables, and impurities – two percent maximum

• Pesticide residue – refer to paragraph later in this article

Feed Grade Fats

Feed grade fats are often stabilized blends of animal and vegetable fats. They are produced in the commercial processes of rendering offal from livestock and poultry tissues. Feed fats consist predominantly of triglyceride of fatty acids and contain no added free fatty acids.

Any tallow or grease could come under this category although only the low-grade tallow or greases are used since they are less expensive. With the expanding use of fats in feed, some feed grade fats may include acidulated vegetable soapstock blended with tallow/greases.

Fats Used as Fuel

Because of their chemical composition, fats release concentrated amounts of energy when burned. This energy can be used as a heat source in industrial boilers or to fuel furnaces. Most fats provide comparable amounts of heat to common fuel oils. Rendered fats, like vegetable oils, can be used to make biodiesel with successful results.

Quality Control Specifications and Tests for Fats

Free Fatty Acid

One measure of fat quality is the free fatty acid (FFA) content. Fats are normally composed of three fatty acids linked to glycerol via ester bonds. FFAs are produced when those fatty acids are freed by hydrolysis. Therefore the presence of high levels of FFAs indicates the fat was exposed to water, acids, and/or enzymes. Fats should be processed to contain as low a moisture level as is feasible so that hydrolysis does not occur during subsequent storage.

Increased levels of FFAs in fats have been shown to reduce the digestibility and thus energy content of fats. On the average, each increase of 10 percentage units in FFAs results in a corresponding reduction in digestible energy of 1.3 and 1.5 percentage units in weanling and growing pigs, respectively (Powles, et al. 1995. *Journal of Animal Science* 61:149).

A common source of vegetable fats used in blended feed fats is acidulated soapstock. This by-product of edible oil refining has very high FFAs since it was intimately exposed to water and acid during its production. High levels of FFAs should be considered when estimating energy content of fats for feeding. (*Nutrient Requirement of Swine, 10th Revised Edition*. 1998. National Research Council, Table 11-10, p.141, footnote (d).)

The reaction between an alkali and fat or fatty acid is the basis of two important analytical determinations. Firstly, acid value is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids in one gram of fat. Acid value is a measurement that avoids the use of assumed molecular weights as occurs in the FFA determination.

The acidity of fats is also often expressed directly in

Continued on page 16

Table 1. American Fats and Oils Association Specifications for Tallow and Greases

Grades	Titer Min. °C	FFA Max.	FAC Max.	R&B Max.	MIU
1. Edible tallow	41.0	0.75	3	None	*
2. Lard (edible)	38.0	0.50	**	None	*
3. Top white tallow	41.0	2	5	0.5	1
4. All beef packer tallow	42.0	2	None	0.5	1
5. Extra fancy tallow	41.0	3	5	None	1
6. Fancy tallow	40.5	4	7	None	1
7. Bleachable fancy tallow	40.5	4	None	1.5	1
8. Prime tallow	40.5	6	13-11B	None	1
9. Special tallow	40.0	10	21	None	1
10. No. 2 tallow	40.0	35	None	None	2
11. "A" tallow	39.0	15	39	None	2
12. Choice white grease	36.0	4	13-11B	None	1
13. Yellow grease	***	***	39	None	2

°C = degrees Celsius
R&B = Refined and bleached
MIU = Moisture, impurities, unsaponifiables
*Moisture maximum 0.20 percent. Insoluble impurities maximum 0.05 percent.
**Lovibond color 5-1/4 inch cell – maximum 1.5 red. Lard peroxide value 4.0 meq/kg maximum.
***Titer minimum and FFA maximum, when required, to be negotiated between buyer and seller on a contract-by-contract basis.

Table 2. USDA-certified Edible Beef Tallow Technical Specifications

Titer (min.)	41
FAC (max.)	3
Refined and bleached (max.)	None
FFA (max.)	0.75%
Iodine value (max.)	40-45
Initial peroxide value (max.)	1.0 meq/kg
Soap (max.)	5.0 ppm
Moisture and volatiles (max.)	0.1%
Wiley (melting point)	107-114°F (42-45°C)
FAC color index	10 Yellow, 1 Red
Smoke point (min.)	435°F (224°C)
Flash point (min.)	600°F (315°C)

°F = degrees Fahrenheit
Note – These characteristics will ensure a flavorful fried or baked food and a long shortening life in the fryer.
Sources: American Fats and Oils Association, and American Oil Chemists' Society.

Table 3. USDA-certified Lard Technical Specifications

Titer (min.)	38°C
FFA (max.)	0.5%
FAC (max.)	39
Lovibond color (5-1/4 inch cell – max.)	1.5 red
Moisture (max.)	0.2%
Insoluble impurities (max.)	0.05%
PV (max.)	4 meq/kg

Source: American Fats and Oils Association.

Buyer's Guide *Continued from page 15*

terms of percent FFAs. The assumption usually made in the calculation is that the acids have a molecular weight equal to that of an oleic acid. The relation between acid value and percent FFAs calculated as oleic is as follows: one unit of acid value = 0.503 percent FFAs.

i) Free fatty acids as oleic, % =
<u>milliliter (ml) of alkali x N x 282</u>
10 x weight of sample

ii) Free fatty acids as lauric, % =
<u>ml of alkali x N x 200</u>
10 x weight of sample

iii) Free fatty acids as palmitic, % =
<u>ml of alkali x N x 256</u>
10 x weight of sample

Note – N = normality or strength of alkali. 282, 200, 256 = molecular weights of the respective fatty acids.

In many types of fats and oils the percentage of FFAs is calculated as oleic acid, but with coconut and palm kernel oils it is expressed in terms of lauric acid and in palm oil as palmitic acid.

Biodiesel plants having either a pre-treatment system or acid esterification system can make use of higher FFA fats/oils. The price of the product should generally reflect the yield loss or increased processing cost compared to a low FFA fat/oil.

Table 4. Chemical Data of Feed Grade Fats: Average Values

Fat Source	°C Titer	% MIU	Max. % FFA	Iodine Value	U/S	% Fatty Acids Sat.	Unsat.	Linoleic
FGF – for all feeds	29-45	2-4	40	40-100	1.0–3.0	25-50	50-75	4-40
FGF – for milk replacers	38-41	1	5	47	1.0	50	50	4
Beef tallow	38-43	1	5	47	1.0	50	50	4
Pork fat	32-37	2	15	68	1.6	38	62	12
Poultry fat	28-33	2	15	85	2.6	28	72	20
Acidulated vegetable soapstock	28-35	4-6	70	32	4.1	20	80	2
Palm oil	28-36	2	5	53	1.4	42	58	10

FGF = Feed grade fat
U/S = Unsaturate/Saturate ratio

Color

FAC is the abbreviation for the Fat Analysis Committee of the American Oil Chemists' Society. A sample of fat is filtered then compared with standard color slides mounted on a circular aperture. FAC color standard runs from one to 45 using odd numbers divided into five series for grading:

- 1-9 = light colored fats
- 11, 11A, 11B, 11C = very yellow fats
- 13-19 = dark, reddish fats
- 21-29 = greenish fats
- 31-45 = very dark fats

The different series are somewhat independent so there is no orderly increase in the color from the lowest to the highest numbers, i.e., fats graded 21-29 may actually be lighter than those graded 13-19. The FAC method is used when fats are too dark or green to be read by the Lovibond method.

Many customers require low FFA and color so that they can maximize the yield of products they manufacture from tallow. A low FFA results in a high glycerin yield for the soap manufacturer. Similarly, a low color tallow enables the manufacturer to produce high quality white bath soap or high quality fatty acids.

A refined and bleached analysis determines the Lovibond color of the sample after treatment with alkali and a specified bleaching earth. The Lovibond color is a much finer color reading compared to the FAC color standards. The color is reported as red and yellow. For example, a good extra fancy tallow will read 0.5 red and five yellow. In reading tallow, the yellow is 10 times the red (0.5 x 10 = five yellow).

The biodiesel producer will see a color impact slightly in the fuel color, but mostly in the glycerin product. Very dark glycerin may be discounted in the market, depending on the end use of the glycerin.

Moisture, Impurities, Unsaponifiables

A sample of fat is weighed and the moisture is boiled off. The weight loss is calculated as the moisture content.

The recommended moisture level is one percent or less. Moisture can reduce the energy of a fat both by dilution and by causing an increase in the FFA content. Some condensation moisture is unavoidable with any feeding fat; however, it should be kept at a minimum. Moisture at low levels functions much like an antioxidant, but at higher concentrations is a pro-oxidant presumably because if can solubilize trace metals (*Bailey's Industrial Oil and Fat Products, 4th Edition*, vol. 1, p.147). Moisture accumulates in the lower strata of fat storage units, which makes sampling difficult. Therefore, prior to sampling fat in storage, it should be thoroughly mixed by mechanical agitation.

Impurities are non-hazardous filterable materials not soluble in petroleum ether. However, impurities can create physical problems as they settle to create tank sludge and ultimately clog valves, lines, and nozzles. Impurities could be meat and bone particles remaining in the tallow after the rendering operation even though it is filtered, or it could be foreign materials such as sand or metal particles picked up after processing during storage and/or transport.

The same sample that moisture was determined from is filtered through a fine filter paper using a solvent. The weight of the material left on the filter paper is a measure of the insoluble impurities.

Unsaponifiables, or "unsaps," refers to any material within the tallow that will not saponify (convert into soap) when mixed with an alkali. This basically covers components of the tallow that are not triglycerides such as plant sterols and pigments. A major portion of the unsap fraction is from plant sterols originating from the gut contents (forages, grains) of rendered offal. The determination of unsap content is based upon saponification followed by extraction with solvents and washing.

Biodiesel producers should request as low a value of moisture, impurities, and unsaponifiables as possible as these will impact biodiesel end product quality. Moisture in the fats/oils will generate soaps in the methylester that must be removed and will interfere with the separation process of the glycerin.

Formation of soaps also interferes with the catalyst, binding it and increasing cost through increased need for methanol and catalyst. The unsap portion is also an indicator of likely filterability issues in the finished product and will need to be removed from the methylester, if it has not been removed from the oil prior to transesterification.

Polyethylene

Almost all tallow contains polyethylene (PE), which is a foreign material in tallow, to some degree. It finds its way into the rendering plant as meat wrappers mixed in with the raw material. Most of the polyethylene wrappers used by the meat industry are of low density type that will melt at lower temperatures and stay soluble in the tallow.

At present the only feasible means of removing PE from tallow is to filter the tallow at low temperature using special filter aids. Most tallow consumers say they could stand up to 30 parts per million (ppm) while others indicate they could take as high as 200 ppm.

The problem with PE is that it does not stay soluble in all the various stages of the manufacturing process. In particular, if there is a sharp temperature drop the PE will come out of solution. With soap manufacturers it has been known to adhere to the inside wall of pipes and after it builds up darkened pieces flake off that later show up in the finished bar soap. It has also been known to cause blockage in fatty acid manufacturing plants and can coat the catalyst.

In biodiesel production, the PE will act the same as unsaps and will drop out of the methylester when it is exposed to sharp temperature drops.

Table 5. Typical Fatty Acid Profiles of Tallow and Yellow Grease

Tallow Fatty Acid	%	Yellow Grease Fatty Acid	%
Myristic	2.9	Lauric	–
Myristoleic	0.3	Myristic	0.5-3.0
Pentadecanoic	0.6	Palmitic	14.0-24.5
Palmitic	25.8	Stearic	7.0-15.5
Palmitoleic	2.0	Oleic	43.0-46.0
Stearic	21.5	Linoleic	8.0-29.0
Oleic	42.6	Linolenic	0.6-2.5
Linoleic	2.3		
Linolenic	0.2		

Table 6. Ranges of Titers for Different Fats and Oils

Fat or Oil	°C
Babassu oil	22-23
Beef tallow	40-47
Castor oil	2-4
Coconut oil	20-24
Corn oil	14-20
Cottonseed oil	30-37
Lard	32-43
Linseed oil	19-21
Olive oil	17-26
Palm oil	40-47
Palm kernel oil	20-28
Peanut oil	26-32
Rapeseed oil	11-15
Sardine oil	27-28
Sesame oil	20-25
Soybean oil	21-23
Whale oil	22-24

Titer

Titer is a measure of the solidification point of a fat after it has been saponified and the soaps reacidulated to FFAs. It is determined by melting the resulting fatty acid, and while slowly cooling, measuring the congealing temperature in degrees centigrade.

The titer is an important characteristic of inedible fats used for soap making to make harder soap, or as raw materials for fatty acid manufacture, and is also an indication of the firmness of natural edible fats such as lard. Under the accepted United States trading rules, inedible fats with titers below 40 degrees centigrade are classed as grease and those with higher titers are classed as tallow. Minimum titers are also specified for the different grades.

A good rule of thumb is when a sample of tallow stays liquid in a warm room, it has a low titer and if it hardens in a warm room it has a high titer. The reason for fat to have a high or low titer is due to its constituent saturated and unsaturated fatty acids (the higher the degree of unsaturation, the lower the titer).

Titer cannot be changed in the rendering plant; however, it can be greatly increased by a hydrogenation process in which hydrogen is added to the unsaturated bonds.

Iodine Value

The iodine number is a measure of the chemical unsaturation of the fat and the results are expressed as the number of grams of iodine absorbed by 100 grams of fat sample. Iodine value (IV) can be used to estimate fat structure and unsaturation-saturation ratios. Unsaturated fats have higher IVs than saturated fats, so the higher the IV, the softer the fat and lower the titer.

Rate of Filtration

This method was originated by Proctor and Gamble to ensure they were receiving clean tallow. Fats that will give processing difficulties such as slow filtration, emulsions, and foaming can be detected by this filtration method. The method is based on the amount of fat that will filter in a specified time under standard conditions.

The results from this test could run 40, which means 40 milliliters of tallow at 230 degrees Fahrenheit (110 degrees Celsius) passed through the filter paper in five minutes. Proctor and Gamble likes to purchase tallow with 35 to 40 rate of filtration. (Filter paper is VWR International, LLC, grade 417.)

Continued on page 18

Buyer's Guide *Continued from page 17*

Microscopic fines, polyethylene, and plant gums from the raw material could cause a slow filtration by plugging the pores of the filter paper, thus resulting in a very low rate of filtration. Tallow that has been water washed or pre-filtered will generally run a high rate of filtration due to removal of fines and gum.

This test can be helpful to biodiesel producers as a predictor of issues with filterability of finished methylester, but the rate of filtration must be calibrated to the specific biodiesel process. This test has not been correlated to the ASTM cold soak filtration test. Such a correlation between raw materials, processing parameters, and the finished product test might benefit the biodiesel and rendering industries as both try to understand field performance of biodiesel under various temperature and equipment conditions.

Pesticide Residues

Reputable renderers have implemented good manufacturing practices that prevent accidental contamination of rendered products by exposure to crop chemicals and PCBs. Hazard analysis and critical control point programs dictate products are not released for sale until being certified that U.S. Food and Drug Administration specifications are not exceeded. Some of these pesticide residues and their maximum levels are: DDT, DDD, DDE - 0.5 ppm; Dieldrin - 0.3 ppm; and PCB - 2.0 ppm. The method of analysis is by gas chromatography.

Saponification Value

This is an estimate of the mean molecular weight of the constituent fatty acids in a fat sample and is defined as the number of milligrams of potassium hydroxide required to saponify one gram of the fat. The higher the saponification value, the lower the mean chain length of the triglycerides.

Boehmer Number (Applied to Lard)

This test is used to determine if tallow is mixed with lard. For pure lard, the number should be greater than 73. If less than 73, it indicates contamination.

Fatty Acid Profile

The fat is saponified and then methyl esters are formed. These methyl esters of the component fatty acids are then injected onto a gas chromatograph column and the fatty acids

Table 7. Final Melting Points of Average Samples of Fats and Oils

Fat or Oil	°C
Babassu oil	26
Beef tallow	50
Butterfat	37
Cocoa butter	36
Coconut oil	26
Cottonseed oil	11
Lard, prime steam	45
Palm oil (refined)	40
Palm kernel oil	29
Peanut oil	13
Hydrogenated Oils	
Castor	87
Cottonseed	60
Sardine	57.5
Soybean	66.5

Table 8. Iodine and Saponification Value of Samples of Vegetable Oils and Animal Fats

Fat or Oil	Iodine Value	Saponification Value
Coconut oil	7.5-10.5	250-264
Corn oil	103-128	187-193
Cottonseed oil	99-113	189-198
Lard, prime steam	53-77	190-202
Palm oil	44-58	195-205
Soybean oil	120-141	189-195
Tallow – beef	35-48	193-202
Tallow – goat	33.5	199
Tallow – mutton	41.2	197

Table 9. Quality Control Analysis with Approximate Running Times

No.	Lab Test	Time Involved
1.	FFA	5 minutes
2.	Color	5 minutes
3.	Moisture	15 minutes
4.	Insolubles	10 minutes
5.	Unsaponifiables	3 hours
6.	Refined and bleached	2 hours
7.	Polyethylene	2 hours
8.	Titer	4 hours
9.	Bleach test	25 minutes
10.	Rate of filtration	30 minutes
11.	Refining loss	6.5 hours
12.	Iodine value	2 hours
13.	Saponification value	3 hours
14.	Fatty acid profile	30 minutes
15.	Protein	2 hours
16.	Fat	2.5 hours
17.	Ash	2.5 hours
18.	Protein digestibility	28 hours
19.	Yield test	8 hours
20.	Alkalinity, phenophthalein	20 minutes
21.	Alkalinity, methyl	20 minutes
22.	Chlorides	20 minutes
23.	Sulphite	20 minutes
24.	pH	5 minutes
25.	Phosphate	20 minutes
26.	Total dissolved solids	5 minutes
27.	Hardness	15 minutes
28.	Aflatoxin	30 minutes - 3 hours
29.	Pesticide residue/PCBs	8 hours
30.	Chick edema	8 hours
31.	Microscopic check	15 minutes
32.	Microscopic test (complete)	4 hours
33.	Gossypol	3 hours

are separated due to their differing solubility in the liquid phase of the column. The fatty acids elute from the column and are burnt in a hydrogen flame. The increased electric activity generated by the incineration is recorded and the percent fatty composition of the fat calculated.

With the development of column technology, the fatty acid composition can be determined within 20 minutes of the sample being taken.

Total Fatty Acids

Fat quality is determined by energy value, stability, and freedom from extraneous materials. Total fatty acids (TFAs) are comprised of both free fatty acids and those combined with glycerol (intact glycerides). Fat is composed of approximately 90 percent fatty acids and 10 percent glycerol. Glycerol contains about 4.32 calories per gram compared with 9.40 calories per gram for fatty acids. Since fatty acids contain over twice the energy of glycerol and are the primary energy source in feeding fats, the TFA content acts as one indicator of energy. TFA levels less than 90 percent reflect dilutions with other ingredients and the value should be discounted on total fatty acid content.

Lead

The U.S. Food and Drug Administration specification for lead is 7.0 ppm. Lead is considered to be a toxic substance in concentrations greater than this level. The methods of analysis are by atomic absorption, inductive-coupled plasma analysis, or by ultraviolet spectrophotometry.

Peroxide Value

The peroxide value (PV) method is a common way of assessing fat rancidity. Rancidity is primarily caused by oxidation with hydroperoxides being the first oxidation products formed. The PV method measures their formation by determining the amount of iodine liberated from their reaction with potassium iodide and expressing the result in milli-equivalents per kilogram (meq/kg). Hydroperoxides are further oxidized to aldehydes and ketones, which are responsible for the changes in odor and flavor of rancid fats. The human threshold for detecting these changes seems to correspond to a PV of about 40 meq/kg. If a fat has a PV less than 40 meq/kg and does not smell rancid, it is most likely in the initial stages of oxidation and can readily be used in feed rations. If the PV is less than 40 meq/kg and the fat smells rancid, it is likely in its later stages of oxidation.

Conclusion

While the above are industry standards and recommendations, biodiesel producers looking to buy rendered fats should know the specifications required by their particular process and communicate those requirements to the supplier, who may be able to supply products lower than the maximum value at an appropriate premium to the published commodity prices.

Commodity prices are for those products typical or even at the limits of the ranges and may not reflect prices for better than average values. **R**