POCKET INFORMATION MANUAL
A BUYER'S GUIDE TO RENDERED PRODUCTS

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CONTENTS

NRA and its Market Development Program 5

Abbreviations of Terms 9

PRODUCTS AVAILABLE FROM THE RENDERING INDUSTRY 10

1.1 Fats:

a) Industrial Tallows 10
b) Edible Beef Tallow 11
c) Lard 13
d) Yellow Grease 14
e) Feed Grade Fats 14
f) Fats used as Fuel 15

Definitions of Energy Terms 17

1.2 Quality Control Specifications and Tests on Fats and Oils

a) Free Fatty Acid (FFA 18
b) Color 20
c) Moisture, Impurities, Unsaponifiables (MIU) 21
d) Polyethylene 22
e) Titer 23
f) Iodine Value 25
g) Rate of Filtration 25
h) Pesticide Residues 25
i) Saponification Value 26
j) Boehmer Number 26
k) Fatty Acid Profile 26
l) Total Fatty Acids 27
m) Lead (heavy metal) 27
n) Chick Edema 27
o) Peroxide Value 28

2.1 Animal Protein Meals

a) Introduction 30
b) Meat-and-Bone-Meal 31
c) Meat Meal 32
d) Hydrolyzed Feather Meal 33
e) Poultry By-product Meal 35
f) Blood Meal 36
g) Specialized Protein Blends 37

2.2 Quality Control Tests and Specifications for Animal Proteins

a)	Protein	38
b)	Fat	38
c)	Moisture	38
d)	Fiber	39
e)	Pesticide Residues	39
f)	Salmonella	39
g)	Digestibility	40
h)	Calcium/Phosphorus	41
i)	Ash	41
j)	10 mesh screen test	41
k)	Microscopic Analysis	41

3. Tables

a) American Fats & Oils Ass. specs. and grades for tallows and greases 12
b) Specifications for Edible Beef Tallow 13
c) Specifications for Lard 13
d) Chemical Data of Feed Grade Fats 16
e) Typical Fatty Acid Profiles of Tallow and Yellow Grease 20
f) Ranges of Titers for Different Fats and Oils 24
g) Final Melting Points of Average Samples of Fats and Oils 24
h) Iodine and Saponification Values of Fats and Oils 26
i) Quality Control Analysis with Approximate Running Times 29
j) Typical Analysis of MBM 32
k) Typical Analysis of Meat Meal 33
l) Typical Analysis of Feather Meal 34
m) Typical Analysis of Poultry By-Product Meal 35
n) Typical Analysis of Low Ash Poultry Meal 36
o) Typical Analysis of Blood meal 37
p) Physical Properties of Blood meal 37
q) Amino Acid Digestibilities of Animal Proteins 42
r) Nutrient composition of animal protein meals 42
s) Solidification Properties of Saturated Fats and Triglycerides 43
t) FAC Lovibond Color Comparison 44
u) Approximate Densities of Commercial Fats 44

NRA and its Market Development Program

The National Renderers Association (NRA) is a U.S. trade organization representing more than 200 companies producing animal and poultry by-products and supplier firms servicing the industry. The association also has an International Membership representing rendering companies and service industries from all continents. (Visit our website at www.renderers.org for a list of members)

The National Renderers Association is headquartered in the Washington DC Metropolitan area (Alexandria, Virginia, USA), with offices in Hong Kong and Mexico City.

The organization was formed in 1933 by a small group of renderers who believed there was a need for a cooperative effort to deal with the problems of the industry.

The association continues to work to resolve current industry issues, to promote demand for rendered products internationally, to sponsor research and development of new product ideas, and to represent the industry to regulatory agencies and the general public.

The NRA works to promote more efficient and increased use of rendered products by arranging educational seminars, organizing trade delegations, sponsoring research and disseminating trade and technical information worldwide.

What are Rendered Products used for? World production of animal fats is more than 6.8 million tonnes of which more than half is 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 3000 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 are 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, form a fourth sector.

Finally, an emerging industrial use is the production of biodiesel from animal fats and recovered cooking oils. Environmental benefits drive the growth of this market.

Despite the constant challenge from competing commodities, animal fats and proteins maintain an important role in world trade. Finding high-value uses for animal by-products is a key component to the sustainability of animal agriculture.

NRA takes pride in contributing to general economic development, protecting animal and public health and benefiting our environment.

INFORMATION MANUAL

A BUYER'S GUIDE TO RENDERED PRODUCTS

For a list of exporters of the products mentioned in this manual, please visit the National Renderers Association website at -

www.renderers.org

The National Renderers Association is grateful for the following information which has been provided by its member companies.

Abbreviations of Terms

FFA	Free Fatty Acids
FAC	Fat Analysis Committee
R&B	Refined and Bleached
MIU	Moisture, Unsaponifiables, Impurities
IV	Iodine Value
PV	Peroxide Value
FGF	Feed Grade Fats
PE	Polyethylene
SV	Saponification Value
meq	Milli-equivalents

PRODUCTS AVAILABLE FROM THE RENDERING INDUSTRY

1.1 Fats:

a) Industrial Tallows*:*

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 230-250ºF (110-120ºC) for three to six hours. At the end of this period, the mixture settles into three phases: a top fat layer which 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 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.

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

The sources from which the renderer obtains his raw materials are:

- Packinghouse by-products, such as organ fats, offal, bones and blood
- Boning house material which consists of bones and meat trimmings
- Meat market trimmings including adipose and inter-muscular fats, bone, cartilage and meat trimmings
- Restaurant greases: Recovered cooking oils (these are processed and stored separately)
- Fallen animals

Table a: American Fats and Oils Association specifications for Tallows and Greases

Grades	Specifications				
	TITER Min ^oC	**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 2	none	2
12) Choice white grease	36.0	4	13-11B	none	1
13) Yellow grease	***	***	39	none	2

* *moisture maximum 0.20%. Insoluble impurities maximum 0.05%*

** *Lovibond color 5 1/4 inch cell - max 1.5 red. Lard peroxide value 4.0 meq/kg max*

*** *Titer minimum and FFA maximum, when required, to be negotiated between buyer and seller on a contract by contract basis*

b) Edible Beef Tallow:

US edible beef tallow is made exclusively from the highest quality edible beef fat processed for human consumption and inspected by the United States Department of Agriculture's (USDA) Food Safety and Inspection Service (FSIS).

US 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 US regulations specifically restrict meat plants to the processing of only one type of animal, no mixing of different animal fats can occur. These USDA regulations ensure that the product is 100 percent pure beef fat. Certified Halal and Kosher tallow are also available in the US.

Table b: USDA-certified Edible Beef Tallow has the following technical specifications*:

Titer (min)	41
FAC (max)	3
R&B (max)	none
FFA (max)	0.75%
maximum Iodine value	40-45
Initial peroxide value	1.0 meq/kg max
Soap	5ppm max
Moisture and volatiles	0.1% max
Wiley melting point)	107-114^{o}F (42-45^{o}C)
FAC color index	10 Yellow, 1 Red
Smoke point	435^{o}F min (224^{o}C)
Flash point (min)	600^{o}F (315^{o}C)

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*

c) Lard:

Lard is the fat rendered from fresh, clean, sound tissues of pigs 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 IV) the fat.

Table c: USDA-certified Lard has the following technical specifications:

Titer (min)	38^{o}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)	4meq/kg

Source: American Fats and Oils Association

d) 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 greases. The specifications for yellow grease are as follows:

FFA - 15% max
FAC - 39 max
MIU - 2% max
Pesticide Residue - (refer to 1.2h)

e) 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 soap stock blended with tallows/greases.

The major benefits of using Feed Grade Fats in Animal Feeds are listed here.

They:

- increase the energy density
- provide essential fatty acids to poultry, swine and pets
- improve feed palatability
- enhance nutrient (vitamin) utilization
- improve animal performance (growth rate, feed efficiency, milk production, survival rates and body condition etc.)
- reduce dustiness
- reduce wear and maintenance on machinery
- facilitate shipping of bulk feed
- prevent the separation of mixed feed ingredients

(f) 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. This process produces two products, crude glycerol and biodiesel (methyl or ethyl esters), depending on the type of alcohol used as a catalyst.

Table d: 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
All-beef tallow	38-43	1	5	47	1.0	50	50	4
All-pork fat	32-37	2	15	68	1.6	38	62	12
All-poultry fat	28-33	2	15	85	2.6	28	72	20
Acidulated veg soapstock	28-35	4 - 6	70	32	4.1	20	80	2
Palm Oil	28-36	2	5	53	1.4	42	58	10

*MIU =moisture, insolubles and unsaponifiables
**FFA = free fatty acids
***U/S = unsaturate:saturate ratio

Definitions of Energy Terms

GE: GROSS ENERGY (Kcal/kg) - Total heat produced when a feed ingredient is burned. Measured in the bombcalorimeter.
DE: DIGESTIBLE ENERGY (Kcal/kg) - Gross energy of feed intake minus faecalenergy.
ME: METABOLIZABLE ENERGY (Kcal/kg) - Gross energy of food intake minus energy lost in feces, urine and combustible gases. The 'usable' energy of a feed. – 96% of D.E. (Ref: Nutrient Requirements of Swine, 10^{th} Revised Edition, 1998, NRC)
HI: HEAT INCREMENT (Kcal/kg) - Portion of ME required for the utilization of the remaining net energy for maintenance and production.
NE: NET ENERGY (Kcal/kg) - Metabolizable energy minus heat increment (HI): NE includes the amount of energy used for maintenance and for production.
Nem: NET ENERGY FOR MAINTENANCE (Kcal/kg) - Metabolizable energy minus heat increment (HI) and minus net energy for production (NEp). It is the fraction of NE expended to keep the animal in energy equilibrium.
Nep: NET ENERGY FOR PRODUCTION (Kcal/kg) - Metabolizable energy minus heat increment (HI) minus net energy for maintenance (NEm). The fraction of NE is used for tissue gain and/or work.
TDN: TOTAL DIGESTIBLE NUTRIENTS (%) - Digestible protein, percent + dig. fiber percent + dig.nitrogen-free-extract percent plus 2.25 times the content of digestible crude fat.
GN: GESAMTHAHRSTOFF (g/kg) - Same as TDN but with factor 2.3 for digestible crude fat.
EW: ENERGIEWAARDE (Kcal/kg) - EW 2.59 digest. prot. + 8.63 digest. ether extract + 1.5 percent digest. fiber + 3.03 digest. N-free-extractives.

1.2 Quality Control Specifications and Tests for Fats

a) Free Fatty Acid (FFA):

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. FFA are produced when those fatty acids are freed by hydrolysis. Therefore the presence of high levels of FFA 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 FFA 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 FFA 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 FFA since it was intimately exposed to water and acid during its production. High levels of FFA should be considered when estimating energy content of fats for feeding. (Ref: Nutrient Requirement of Swine, 10th Revised Edition, 1998, National Research Council, see Table 11-10, p141, footnote *(d))*

Calculations for DE of fats: -

1. Pigs (10-20 kg): DE (kcal/kg) =
   $(36.898 – (0.005 \times FFA) – (7.33 \times e^{-0.906}))/4.184$
2. Pigs (35-85 kg): DE (kcal/kg) =
   $(37.890 – (0.005 \times FFA) – (8.20 \times e^{-0.515 \times U:S}))/4.184$
3. Chicks (1.5 wks): AME (kcal/kg) =
   $(38.112 – (0.009 \times FFA) – (15.337 \times e^{-0.509 \times U:S}))/4.184$
4. Chicks (6 wks): AME (kcal/kg) =
   $(39.050 – (0.006 \times FFA) – (8.505 \times e^{-0.403 \times U:S}))/4.184$,
   (where FFAs are expressed in g/kg. ME = DE x 0.96)

The reaction between an alkali and fat or fatty acids 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 terms of percent Free Fatty Acids (FFA).

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 free fatty acids calculated as oleic is as follows: *1 unit of acid value = 0.503% free fatty acids*

i) Free fatty acids as oleic, % =

$$\frac{\text{ml of alkali x N x 282}}{\text{10 x weight of sample}}$$

ii) Free fatty acids as lauric, % =

$$\frac{\text{ml of alkali x N x 200}}{\text{10 x weight of sample}}$$

iii) Free fatty acids as palmitic, % =

$$\frac{\text{ml of alkali x N x 256}}{\text{10 x weight of sample}}$$

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 free fatty acids 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.

Table e: Typical fatty acid profiles of Tallow and Yellow Grease

Tallow		**Yellow Grease**	
Fatty acid	**%**	**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	7.0-15.50
Palmitoleic	2	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		

b) Color:

(i) 'FAC' is the abbreviation for the Fat Analysis Committee of the AOCS. A sample of fat is filtered then compared with standard color slides mounted on a circular aperture. FAC color standard runs from 1-45 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.

(ii) 'R&B' means refined and bleached.
This 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).

c) Moisture, Impurities, Unsaponifiables (MIU):

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 1% or less. Moisture can reduce the energy of a fat both by dilution and by causing and 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 solublize trace metals (Bailey's Industrial Oil and Fat Products, 4th Edition, P147, Vol. 1). 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. Unsaponifiables contribute little energy to feeding fat.

d) Polyethylene (PE):

Almost all tallow contains PE to some degree. PE is a foreign material in tallow. 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 30ppm while others feel they could take as high as 200ppm.

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 which 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.

e) Titer:

Titer is a measure of the solidification point of a fat after it has been saponified and the soaps reacidulated to free fatty acids. 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 tallows. 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 vice versa. The reason for fat to have a high or low titer is due to its constituent saturated and unsaturated fatty acids.

Table f: Ranges of titers for different fats and oils

Fat or oil	Degrees °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

Table g: Final melting points of average samples of fats & oils

Fat or oil	Degrees °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 oil	87
Cottonseed oil	60
Sardine oil	57.5
Soybean oil	66.5

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 (Tables g and h).

f) Iodine Value (IV):

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 100g of fat sample. Iodine value can be used to estimate fat structure and unsaturation: – saturation (U/S) ratios. Unsaturated fats have higher IV's than saturated fats, so the higher the IV, the softer the fat. Feeding studies with poultry and swine demonstrate a steady increase in metabolizable energy content as the IV and U/S ratio increase for a fat until a plateau is reached around 3.0 (U/S).

g) Rate of Filtration (ROF):

This method was originated by Proctor and Gamble to ensure themselves of clean tallow. Fats which 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^{o}F (110^{o}C) passed through the filter paper in five minutes. Proctor and Gamble likes to purchase tallow with 35-40 ROF. (Filter paper is VWR international Grade 417)

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 ROF. Tallows that have been water washed or prefiltered will generally run a high ROF due to removal of fines and gum.

h) 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 plans dictate products are not released for sale until being certified that US Food and Drug Administration tolerances are not exceeded. Some of these pesticide residues and their maximum tolerances are: DDT, DDD, DDE 0.5ppm, Dieldrin - 0.3ppm; PCB - 2.0ppm. The method of analysis is by gas chromatography.

Table h: Iodine and saponification value of some representative samples of common vegetable and animal fats and oils

Fat or Oil	IV	SV
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

i) Saponification Value (SV):

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 SV, the lower the mean chain length of the triglycerides.

j) 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.

k) 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 chromatographic column and the fatty acids 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 (Table n).

l) Total Fatty Acids (TFA)

Fat quality is determined by energy value, stability and freedom from extraneous materials. Total Fatty Acids (TFA) comprise both free fatty acids and those combined with glycerol (intact glycerides). Fat is composed of approximately 90% fatty acids and 10% 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% reflect dilutions with other ingredients and the value should be discounted on total fatty acid content.

m) Lead (heavy metal):

The U.S. Food and Drug Administration tolerance for lead is 7 ppm. Lead is considered to be a toxic substance in concentrations greater than this tolerance. The methods of analysis are by atomic absorption, inductive-coupled plasma analysis or by ultra-violet spectrophotometry.

n) Chick Edema Factor:

This factor is thought to be a mixture of dioxin dimers. When fed to baby chicks at low levels causes edema. Originally, a bioassay was employed to detect the presence or absence of these compounds. More recently, thin-layer or gas-liquid chromatographic methods have been developed that are more rapid and sensitive.

o) Peroxide Value (PV):

The 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 of < 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 < 40 meq/kg and the fat smells rancid, it is likely in its later stages of oxidation. Feeding studies with broilers have shown that performance is not affected until PV levels in the total diet reached 4 meq/kg. This was equivalent to the fat having a PV of 100 meq/kg and incorporated at 4% of the diet.

Table i: 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.	R & B	2 hours
7.	PE	2 hours
8.	Titer	4 hours
9.	Bleach Test	25 minutes
10.	ROF	30 minutes
11.	Refining Loss	6.5 hours
12.	Iodine Value	2 hours
13.	Saponification Value	3 hours
14.	Fatty Acid Profile	0.5 hours
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.	TDS	5 minutes
27.	Hardness	15 minutes
28.	Aflatoxin	0.5 - 3 hours
29.	Pesticide Residue/PCB	8 hours
30.	Chick Edema	8 hours
31.	Microscopic check	15 minutes
32.	Microscopic Test(complete	4 hours
33.	Gossypol	3 hours

PRODUCTS AVAILABLE FROM THE RENDERING INDUSTRY

2.1 Animal Protein Meals:

a) Introduction

Proteins are compounds of large molecular weight and contain carbon, hydrogen, nitrogen and with a few exceptions sulphur. Amino acids are the fundamental structural units of proteins and are the end result of the complete hydrolysis of proteins. It is these amino acids that animals require in their diet, not the protein itself. There are 23 or more different amino acids. The amino acids which cannot be made in the body from other substances are called the essential amino acids. The most limiting are lysine, tryptophan, threonine and methionine + cystine.

Animal protein meals are produced from the solid material remaining after being thermally pasteurized and separated from the fat portion of animal tissues. The solid material is then finely ground to produce free flowing meal.

Rendered protein meals are moderate to rich sources of protein, amino acids, energy, calcium and phosphorus, essential fatty acids and other vital nutrients. They are also relatively undegradeble in the rumen and consequently have high bypass protein values. However, in the United States and many other countries, meat and bone meal made from raw materials of ruminant origin cannot be fed to cattle, sheep, goats or other ruminant animals. These materials can be fed to swine, poultry, dogs, cats, fish and other monogastric animals.

Products:

a) Meat and bone meal
b) Meat Meal
c) Hydrolyzed Feather Meal
d) Poultry By-Product Meal
e) Blood Meal
f) Specialized Protein Blends

Major benefits of using animal protein meals are:

- They contain moderate to high levels of amino acids like lysine, methionine and threonine.
- If processed properly, the amino acids are highly available.
- They are rich sources of available phosphorus, calcium and trace minerals.
- Highly effective bypass protein for ruminants.
- They help sustain animal agriculture by transforming waste animal tissues into valuable products for further economic use.
- They are palatable when used in diets that are balanced for amino acids, especially lysine, methionine (and cystine), tryptophan, threonine and (for blood meal) isoleucine.

b) Meat and Bone Meal:

Meat-and-bone-meal is the protein residue after the moisture and fat has been extracted in the normal rendering process as described in Section 1. It includes bone, but is exclusive of blood and extraneous material such as hair, hoof, horn or manure. It is golden to medium brown in color, with a fresh meaty odor, and is available throughout the year.

The quality and composition of the raw materials used will have some effect on the quality of finished product. Raw materials may vary in different geographic areas. Consequently, the composition of MBM will vary from plant to plant. MBM customers can manage this variability by identifying individual MBM manufacturing facilities having low variability, or by relying upon MBM blenders that with the capability of reducing the coefficient of variation in protein content to < 3%.

Processing has the greatest effect on amino acid digestibility. Advances made in processing methods and equipment has resulted in marked improvements in the digestibility of meat and bone meal in the past 20 years.

Meat-and-bone-meal may be used as an amino acid source in formulating feeds for all classes of poultry, swine, many exotic animals, some species of fish and pet foods. In 1997, the FDA implemented the "feed ban" rule (21CFR589.2000) that prohibits the feeding of MBM containing ruminant proteins back to ruminants.

Table j: Typical Analysis of MBM

Protein	50% (or as specified)
Fat	10%
Fiber (max)	3%
Calcium (max)	2.2 times actual phosphorus level
Phosphorus (min)	4%
Moisture (max)	10%
Pepsin indigestible Residue (max)	14%

c) Meat Meal:

Meat meal is the solid protein residue derived from the rendering process as described in section 1. It is exclusive of blood, bone and other extraneous material. The product is golden brown in color with a fresh meaty odor.

The quality and composition of the raw materials used will have some effect on the color and composition of the finished product, but has no effect on digestibility. Raw materials may vary in different geographic areas.

Processing has the greatest effect on amino acid digestibility. Advances made in processing methods and equipment has resulted in marked improvements in the digestibility of meat meal in the past 20 years.

Meat Meal is available all year, and may be used as a protein source in formulating feeds for all classes of poultry, swine, exotic animals, fish and pet foods. As with MBM, ruminant containing meat meals are not to be fed to ruminants.

Table k: Typical Analysis of Meat Meal

Protein (min)	55% (or as specified)
Fat	10%
Fiber (max)	3%
Calcium (max)	2.2 actual times phosphorus level
Phosphorus (max)	4%
Moisture (max)	10%
Pepsin Indigestible Residue	14%

d) Hydrolyzed Feather Meal:

Hydrolyzed feather meal is derived by cooking under pressure the clean, undecomposed feathers from slaughtered poultry. It must be processed for sufficient time to break the cystine bonds and produce a meal with a minimum of 70-75% pepsin digestibility.

The prime factor which will influence the quality of hydrolyzed poultry feathers is the degree of hydrolyzation. Too high a hydrolyzation (that is, a pepsin digestibility of 90 percent) will produce overcooked meal with reduced aminto acid digestibility. Likewise, too little hydrolyzation (ie, a pepsin digestibility below 65 percent) will result in an undercooked meal, also with low amino acid digestibility.

Raw feathers have a high cystine content and during processing the cystine linkage is broken, which increases the value of the feather meal. If too many cystine bonds are broken, however, excess sulfur amino acids are destroyed and unnatural compounds are produced. These compounds are digestible in pepsin under laboratory conditions, but are unavailable to the animal.

The physical properties of feather meal vary according to the feathers used; feathers of a light color result in a light golden brown meal; feathers of a dark color result in a dark brown-black meal. Feather meal has a fresh odor. If blood is added to the meal after processing, the color will be darker, but the meal will benefit accordingly from its inclusion.

Feather meal is resistant to rumen degradation and is a valuable bypass protein source for ruminant rations.

Table I: Typical Analysis of Feather Meal

Protein	80%
Phosphorus	0.75%
Fat	5%
Ash	4%
Fiber (max)	4%
Moisture (max)	10%
Pepsin Digestibility min)	75%

The protein content of feather meal is about 80 percent.

The fat content in feather meal varies significantly depending on contamination of the feathers with skin tissue. High quality feather meal should contain less than 5 percent fat.

Moisture should not exceed 10 percent. Very low moisture content may indicate overheating, which would destroy amino acids.

Its digestibility will vary with type of equipment used to process feather meal. If properly hydrolyzed (under pressure), the digestibility will be around 80 percent.

e) Poultry By-Product Meal:

(i) Poultry By-Product Meal consists of the ground rendered parts of the carcasses of slaughtered poultry, such as heads, feet, undeveloped eggs and intestines, exclusive of feathers, except in such trace amounts as might occur unavoidably in good manufacturing practices.

With consumers purchasing poultry meat cuts rather than whole carcasses, the protein content of the poultry by-product meal approximates 58 percent, reflecting the higher bone content of the raw material. Adulteration with raw feathers will alter the amino acid content and decrease digestibility.

This product should be treated with an anti-oxidant immediately after processing to ensure fat stability.

Poultry by-product meal will be golden to medium brown in color, with a fresh poultry odor. The product may be used as an amino acid source in formulating feeds for all classes of poultry, livestock, many exotic animals and pet foods.

Table m: Typical Analysis of Poultry By-Product Meal

Protein	58%
Fat	11
Fiber (max)	3%
Ash (max)	18%
Moisture (max)	10%

(ii) Low ash poultry meal: The principal sources of raw material come from unused chicken and turkey materials created at each level of the meat processing chain. Chicken and turkey skin, carcasses, offal, and fat are collected and processed daily.

Various processing methods are employed to remove mineral containing components resulting in a product with reduced mineral content, increased digestibility and increased levels of essential amino acids. Benefits include renal health in pets and improved water quality of intensive aquaculture systems. The product is golden brown, having a typical poultry meal aroma.

Table n: Typical Analysis of Low Ash Poultry Meal

Item	Target %	Minimum %	Maximum %
Crude Protein	68.	66.0	73.5
Moisture	4.	3.0	6.0
Crude Fat	15.	13.0	18.0
Crude Fiber	1.		3.0
Ash	9.	8.0	11.0
Ca/P ratio	<2.		
Phosporus	1.	1.1	2.2
Pepsin digestibility	89.	85.0	

f) Blood Meal:

Blood meal is a finely ground protein residue derived from clean, fresh blood, excluding all extraneous material such as hair, stomach belchings and urine except in such traces as might occur unavoidably in good manufacturing process.

Moisture is removed from the crude blood by dewatering, followed by ring, flash or spray drying.

The method of drying blood is probably the greatest single factor that will influence the quality of the finished product. Sustained high drying temperatures can bind or inactivate a large percentage of the lysine, as well as other amino acids, making them unavailable to monogastric animals. Spray drying is one method that produces blood meal that is highly digestible. Lysine digestibility improves as the method of drying moves from ring drying <flash drying<spray drying.

In many regions, the plasma is harvested from whole blood, resulting in plasma proteins and blood cells, which are usually spray dried. Both products are high in quality and are primarily used in diets for young pigs or in milk replacers.

The protein content of whole blood meal is at least 80 percent and the protein digestibility is a minimum of 95 percent.

Blood products are a rich source of essential amino acids for swine and poultry. Whole blood is a prime example of a highly undegradable protein for ruminants with more than 75 percent of the protein bypassing to the small intestine. This bypassed protein has a good quality of amino acids that are highly digestible in the lower gut. The product may be used as a protein source in formulating feeds for all classes of poultry, livestock, many exotic animals and some species of fish.

Table o: Typical Analysis of Blood Meal

Protein	85%
Fat(min-max)	0.5-2.0%
Fiber (max)	2%
Ash (max)	5%
Moisture (max)	10%
Lysine (total)	6%
Lysine (available)	80-90%

Table p: Physical Properties of Blood Meal

Color	- uniform, reddish brown
Odor	- fresh
Texture	- Fine granulose, 98% to pass a US No10 Screen
Solubility	- Insoluble in water

g) Specialized Protein Blends:

These are blends that can contain blood meal, feather meal, meat and bone meal, meat meal, and poultry by-product meal designed to contribute specific nutrient advantages to the diets of various species. Specific advantages might include cost effective contributions of metabolizable protein, available phosphorus, and digestible amino acids.

2.2 Quality Control Tests and Specifications for Animal Proteins

a) Protein:

While most meat-and-bone-meals are sold on the basis of 50 percent protein there are instances where meals can be sold containing other protein levels.

An accurate knowledge of rendered animal proteins content and biological availability to poultry and swine is essential. Apparent digestibilities of amino acids are determined at the end of the small intestine and called 'ileal' digestibilites. Some representative apparent ileal digestibility values of the rendered animal protein products are shown in the following table.

b) Fat:

The fat content of meat-and-bone-meal is the residual fat left in the product after centrifuging and pressing, it usually averages eight to12 percent.

c) Moisture:

The moisture content in meat-and-bone-meal is the residual water after the raw material has been cooked and it usually varies between three to five percent. If it is low (one to two percent) it could indicate over cooking.

Moisture content of the meal is critical in rendering operations. High moisture content will adversely affect the quality of the meal so the moisture content is limited to a maximum of 10 percent.

There are several ways to analyze for moisture. For example, a sample can be placed in a forced-air oven at 105°C for two hours and the moisture calculated by weight difference. Another method could be to use a moisture balance which gives the percentage of moisture in about fifteen minutes. The quickest method is to place a sample in the Neotec moisture machine and in a few seconds get a moisture content reading.

d) Fiber:

Fiber is a relatively insoluble carbohydrate, such as cellulose or other structural carbohydrates that are not easily digested.

The crude fiber content in meat-and-bone-meal normally runs below three percent and is present due to remnants of vegetable material found in the rendered offal. This low level has no nutritional relevance. By contrast, soybean meal contains four to seven percent crude fiber which does impact its utilization by baby pigs and many species of fish.

e) 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 plans dictate products are not released for sale until being certified that US Food and Drug Administration tolerances are not exceeded. Some of these pesticide residues and their maximum tolerances are: DDT, DDD, DDE 0.5ppm, Dieldrin - 0.3ppm; PCB - 2.0ppm. The method of analysis is by gas chromatography.

f) Salmonella:

Samonella is ubiquitous. There are more than 2,200 salmonella serovars and even though all may potentially produce disease, the reality is that only about 10-15 serovars are routinely isolated in the majority of clinical salmonellosis in humans and livestock/ poultry.

Although many government recommendations call for zero tolerance on salmonella in any feed ingredient, the most common source of salmonella contamination in livestock and poultry is from other animals. A 1993 survey by the FDA reported that the likelihood of vegetable or animal based proteins testing positive for Salmonella was nearly the same.

Salmonella are readily killed by temperatures used in traditional rendering processes. However, post-process contamination during handling, storage and transportation can still occur just as it does with any feed ingredient. Currently the only method available to prevent Salmonella contamination of feeds or feed ingredients during transport and storage is through chemical treatments that provide residual activity during this period of time

Salmonella are sometimes isolated from rendered animal protein meals, but research findings indicate that the Salmonella isolates from rendering are not the serovars that traditionally cause disease in livestock/poultry and humans. Nonetheless, the Animal Protein Producers Industry (the product safety arm of the North American rendering industry) has recommended the development of Good Manufacturing Practices and Hazard Analysis & Critical Control Points plans for the control of potential product safety hazards like Salmonella.

g) Digestibility:

This is the percentage of feedstuff taken into the digestive tract that is absorbed into the body. Meat-and-bone-meal will have a digestibility of 85 percent or higher.

The digestible protein can be reduced by above average content of materials such as hooves, horns, hair and raw feathers.

h) Calcium/Phosphorus:

The calcium/phosphorus ratio in meat-and-bone-meal is 2:1 with the actual content being about 9 percent calcium and 4.5 percent phosphorus, although the percentage varies from one renderer to another depending on the composition of their raw material.

The high phosphorus availability of meat and bone meal is one of its major nutritional advantages. NCR cites 90% for swine. For poultry, phosphorous from meat and bone meal is as available as that from monosodium phosphate, dicalcium phosphate or mono-dicalcium phosphate.

i) Ash:

This is the percentage of the residue (mineral matter) remaining after combustion at 600°C for two hours. Charring the sample at 300°C for 30 minutes prior to ashing helps prevent loss of ash during the initial combustion. The ash content varies from renderer to renderer reflecting the ratio of bone to soft tissue being processed and is inverse to protein content.

j) 10 Mesh Screen Test:

This test determines whether the material from the cooker has been ground satisfactorily. 98 percent of the meat-and-bone-meal should pass through a US #10 mesh screen (0.075 $inch^2$ opening or 1,910 micron particle size). Pet food manufactures pay particular attention to this test.

k) Microscopic Analysis:

Used to check rendered protein products for impurities.

Table q: Amino Acid Digestibilities of Rendered Animal Proteins

	Meat and Bone Meal		Whole blood	Spray dried plasma	Poultry byproduct meal	
	Ileal[a]	True[b]			Ileal[a]	True[c]
Lysine	71	82	94	86	84	76
Tryptophan	57	--	92	92	74	--
Threonine	64	79	86	80	74	73
Methionine	84	87	84	63	--	88
Cystine	63	47	--	--	--	54
Isoleucine	68	89	67	83	79	67
Histidine	68	82	95	89	80	76
Arginine	80	86	90	86	87	82

[a] *From Knabe 1996*
[b] *From X. Wang and C. M. Parsons, 1998. Poultry Science, 77:834*
[c] *From M. L.Johnson et al., 1998. Journal of Animal Science, 76:1112*

Table r: Nutrient composition of animal protein meals (average*)

	Meat meal	Meat & bone meal	Hydrolysed feather meal	Poultry by-product meal	Blood meal
Crude Protein %	55	50	80	60	85
Crude Fat%	10	10	6	12	1
Crude Friber %	2	3	3	2.10	1
Crude Ash %	15	28.80	2.80	15.50	4.50
Moisture %	7.50	7.50	7.50	6.50	9.50
Metabolizable Energy (Kcal/kg)	2776	2444	3240	3300	3420
TND (g/kg)	78	69	82	88	94
Calcium %	7.00	9.50	0.33	4	0.30
Phosphorus %	3.50	4.50	0.55	2.00	0.25
Methionine %	0.80	0.70	0.60	1.20	0.60
Methionine & Cystine %	1.15	1.05	3.60	2.20	2.00
Lysine %	3.20	2.75	2.00	2.70	7.00
Tryptophan %	0.50	0.50	0.50	0.50	1.10
Choline (mg/kg)	2100	2000	1090	5940	750

**Average values of U.S. commercial samples decreased by one-half standard deviation (SD) according to actual variability*

Table s: Solidification properties of saturated fats and triglycerides

Fat	Expansion tendency*
Vegetable fats - fully hydrogenated	
Cocoa butter	Not expanding
Coconut oil	Not expanding
Corn oil	Expanding
Cottonseed oil	Not expanding
Linseed oil	Expanding
Olive oil	Not expanding
Palm kernel oil	Not expanding
Palm oil	Not expanding
Peanut oil	Expanding
Rapeseed oil	Not expanding
Sesame oil	Expanding
Shea butter	Expanding
Soybean oil	Expanding
Sunflower oil	Expanding
Animal fats - fully hydrogenated	
Butterfat	Not expanding
Lard	Expanding
Tallow	Not expanding
Marine fats - fully hydrogenated	
Fish oil	Not expanding
Seal oil	Not expanding
Esterified triglycerides -	
Trilaurin	Expanding
Trimyristin	Expanding
Tripalmitin	Expanding
Tristearin	Expanding
Tristearopalmitin	Not expanding

**A fat is characterised as expanding if 250ml of the melted fat in a conical steel pitcher surrounded by air expands significantly when left to solidify at 20℃, 40℃ or 50℃.*

Table t: FAC Lovibond Color Comparison

FAC Color	Lovibond color (Red)	FAC Color	Lovibond color (Red)
5	8-12	31	-
7	13-19	21,23	180-280
9	20-29	23,35	Approx 300
11	30-41	25,37	Approx 350
13, 11A	42-59	27,39	Approx 400
11B	-	41	-
15	60-84	29,43	Over 400
17	85-114	45	Over 400
19, 11C	115-179		

Table u: Approximate Densities of Commercial Fats

Temp °C	Temp °F	g/ml	lbs/ft^3	Kg/m^3
43	110	0.896	55.9	895.5
49	120	0.892	55.6	890.7
54	130	0.889	55.4	887.5
60	140	0.885	55.2	884.3
66	150	0.881	55.0	881.1
71	160	0.878	54.7	876.3
77	170	0.874	54.5	873.1
82	180	0.871	54.3	869.9
88	190	0.867	54.0	865.0
93	200	0.863	53.0	849.1