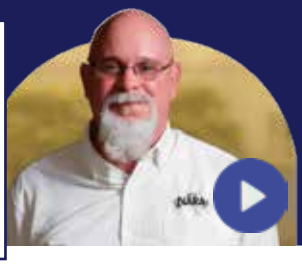
Chap 3.
Quality Control



Introducing
Chapter 3

When we examine meat consumption habits in North America, one reality stands out: a significant share of the animal never makes it to our plates. To turn this challenge into an opportunity, innovative industrial processes were created to transform these “non-edible” parts into valuable resources. At the forefront of this transformation is the Rendering or animal recycling industry, an ecological, regulated, and highly efficient solution that converts by-products into two essential outputs: animal meals and animal fats.

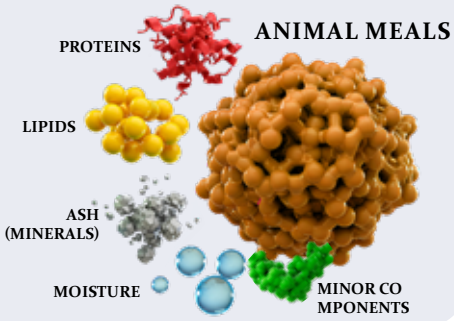
WHAT YOU WILL DISCOVER IN THIS CHAPTER:

- Why rendering is much more than just a recycling process: an ecological solution that transforms non-edible parts into valuable resources.
- What animal meals and animal fats are really made of, with concrete and visual examples.
- The secrets of quality control: how each batch is ensured to be compliant, traceable, stable… and safe.
- For meals: protein content, digestibility, mineral balance
- The invisible but real risks: physical contaminants, impurities, excessive moisture… and how to prevent them.
- The two sides of quality control: the laboratory vs. fieldwork, and why both are essential.
- A revolutionary technology in continuous production: (NIR), how a “digital eye” monitors quality in real time.
- The key analyses for each product:
- For fats: purity, stability, thermal behavior

ANIMAL MEALS

A high value-added solid product, obtained from the transformation of animal by-products.

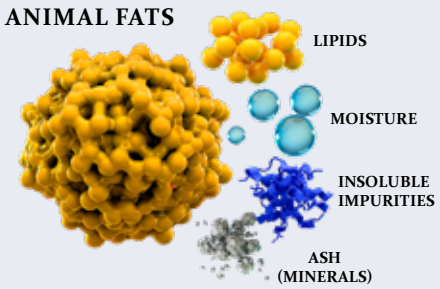
Typical composition: Proteins + Lipids + Moisture + Ash (minerals) + minor components



ANIMAL FATS

A high value-added liquid product, obtained from the transformation of animal by-products.

Typical composition: Lipids + Moisture + Insoluble impurities + Ash (minerals)



The Animal nutrition industry is booming, with a staggering annual growth of +6.5%!

The result? The Rendering industry must keep up the pace, and reinvent itself.

Today, simply recycling animal by-products is no longer enough: **it is necessary to offer high-quality ingredients to formulate properly balanced feeds and comply with increasingly strict health standards, especially for farm animals.** To remain competitive, rendering companies must produce meals and fats that are cleaner, more uniform, and free of contaminants. This requires continuous improvement, from the selection of raw materials to the most rigorous quality controls.

Annual growth of

+6.5%

Quality control of animal meals and fats is a key step to ensure the compliance, safety, and traceability of the final products. In fact, it acts both as a safety net and as a health scanner for the products!

This control relies on two major types of complementary analyses. On one hand, composition analyses make it possible to trace a real "fingerprint" of the product: they identify its nature, origin, and structure, ensuring that it truly corresponds to what it claims to be.
On the other hand, quality analyses tell us about the condition of the product: Is it stable? Well processed? Does it properly meet customer requirements?

These two approaches complement each other and are essential for delivering a reliable, traceable product that meets both market and customer demands.

QUALITY CONTROL ANALYSES ON ANIMAL FATS

Let's begin with **composition analyses**. These analyses allow us to build the product's **"identity document."** Their importance lies mainly in providing a detailed view of the **chemical composition** of the products, as they make it possible to verify that everything matches what is declared, **ensure reliable traceability**, classify them correctly according to current regulations, and identify their chemical behavior. In fact, they are the first line of defense.

FATTY ACID PROFILE:

This is the equivalent of a **fingerprint for an animal fat.** This analysis **identifies and quantifies the types of fatty acids present.**

What is a fatty acid?
It is a partial component of an animal fat, like a link in a chain.

Each link that joins contributes to the total lipid composition of that fat and varies mainly according to the source (pork, poultry, bovine, fish, etc.). With this analysis it is possible to:

1. Confirm the origin of the raw material.
2. Detect product mixtures or fraud in the supply chain.

IODINE VALUE (IV):

This parameter measures the amount of **unsaturation in animal fats.** In a fatty acid, there are straight links (saturated bonds) that are **stable**, and bent links (unsaturated bonds) that are **unstable**. By quantifying the weak links, it is possible to:

1. Confirm **the origin of the raw material.**
2. Evaluate **the product's stability over time.**

UNSAPONIFIABLE MATTER:

This is the proportion of **material that cannot be converted into soap**. It includes all the components of the animal fat that **do not react during saponification**, such as hydrocarbons and other non-ester compounds. This analysis makes it possible to:

1. Evaluate **the purity of an animal fat.**
2. Control **the quality of a processed product.**

SAPONIFICATION VALUE (SV):

This defines the **length of the fatty acid chain links, by quantifying the amount of lye (alkali) needed** to turn one gram of fat into soap. The shorter the fatty acids, the more of them there are in the fat, and the more lye is needed to saponify them. Conversely, if the fatty acids are long, there are fewer of them for the same amount of fat and less lye is needed. The usefulness of this index lies in its ability to identify:

1. **The quality and origin of the fat.**
2. **The most suitable industrial processes depending on the type of fat.**

MELTING POINT (TITRE):

This is the **temperature at which the fat solidifies**. This temperature is an **intrinsic characteristic of its fatty acid composition.** The chain length and degree of unsaturation **define the thermal behavior** of the fat. This value makes it possible to:

1. Identify the composition of liquid fats.
2. Predict the stability and thermal behavior of a product.
3. Control the purity of a fat.

TABLE OF TYPICAL VALUES

Type of Fat	IV (g I_2/100 g)	SV (mg KOH/g)	Unsaponifiables (%)	Titer (°C)
Pork fat	55–65	190–196	~0.8–1.0	32–42
Bovine fat (tallow)	40–50	190–200	~0.9–1.2	42–48
Poultry fat	70–75	195–200	~1.0	25–30
Duck fat	75–80	190–200	~1.0	14–20
Turkey fat	65–75	193–198	~1.0	25–30

Table of Typical Values. Source: Codex Alimentarius, Bailey's Industrial Oil and Fat Products, O'Brien, R.D., Canadian Renderers Technical Guide, USDA Nutrient Database.

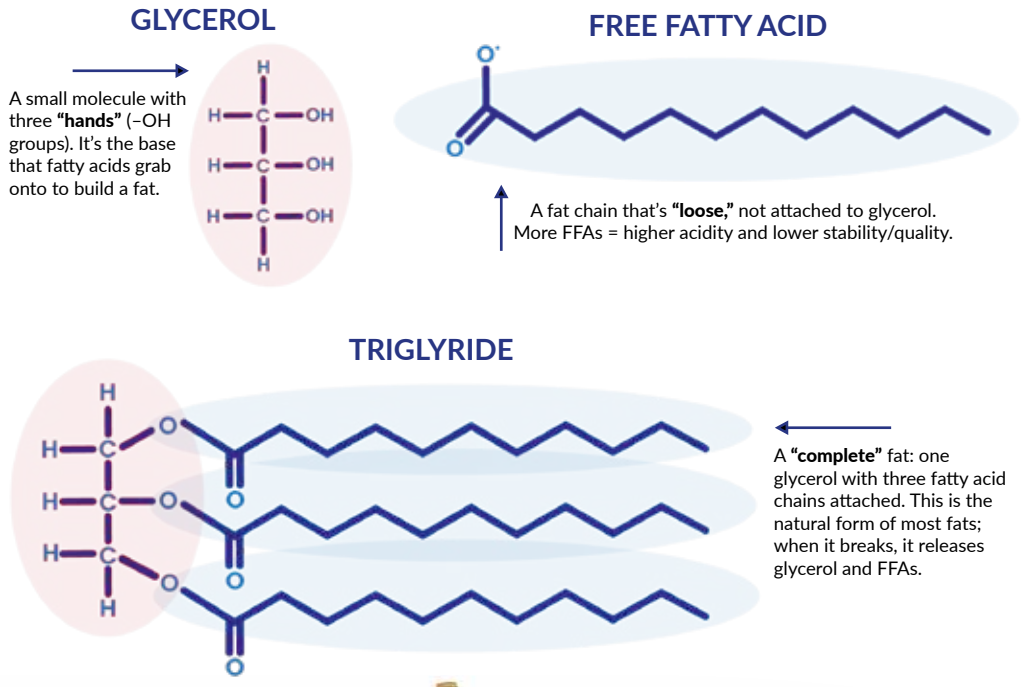
After having analyzed what animal fat contains, let's now look at what can be seen, smelled, and what directly influences its quality on a daily basis.
Some analyses do not refer to the **chemical structure** of the fat, but rather to its **cleanliness, stability, and appearance**. All of these are **essential parameters** to assess whether a fat is of good quality, whether it keeps well, and whether it can be used without causing problems.

FREE FATTY ACIDS (FFA):

This is the **first indicator used to evaluate the quality of the product.** Free fatty acids reflect the "health status" of a fat. When everything is fine, fatty acids are firmly bound to their main molecule, glycerol. But if the fat is poorly stored, overheated, or aged, these fatty acids break away, and the higher their amount, the greater the level of degradation.

TOTAL FATTY ACIDS (TFA):

As the name indicates, this analysis **quantifies the total amount of fatty acids**, including those still bound to the glycerol molecule. This quantification is mainly used as a baseline for comparison.



MOISTURE:

This analysis **measures the water content in a fat**. Water can come from several sources: it can be intrinsic to the product, residual from a process that did not fully evaporate it, or even the result of cross-contamination. One thing is certain: water can quickly become a **danger to the finished product, as it promotes degradation, bacterial growth, or can interfere with later processes.**

IMPURITIES:

This method **quantifies the solid particles present in a fat**. These are **undesirable** particles, with no commercial value, **that can negatively affect industrial processes.**

NOTE ABOUT THE MIU:

In the animal nutrition market, the quality of the fat used is crucial not only for nutritional reasons, but also for economic and technical ones. MIU (Moisture, Impurities, and Unsaponifiables) represents everything that is not useful in a fat. In other words, the **higher the MIU, the more you are paying for water, dirt, or indigestible residues — a direct loss of value!**

DID YOU KNOW?

Did you know that impurities are directly linked to the **risk of transmitting Bovine Spongiform Encephalopathy (BSE)?**

This disease is caused by prions, infectious agents normally found in specific animal parts (bone marrow, brain, eyes, etc.). Since these prions are usually found in solids, **limiting impurities in fat to 0.15% significantly reduces the risk of BSE** transmission through fat used in animal nutrition.

COLOR AND R&B INDEX:

The color analysis of a fat is not just an aesthetic issue. It allows for **quickly identifying the degree and quality of a product**: a fat with low color indices is usually “cleaner,” less oxidized, and therefore of better quality.

TABLE OF TYPICAL VALUES

Type of animal fat	Main final use	Recommended FFA (%)	Comments
Beef tallow	Animal nutrition (feed, pet food)	Ideal: ≤ 10 % Maximum allowed: ≤ 15 %	Low FFA ensures better digestibility and stability.
	Biofuels / energy	Ideal: ≤ 15 % Acceptable: 15–25 %	Transesterification tolerates higher levels; very high FFA requires pretreatment.
	Oleochemicals (soaps, fatty acids)	Ideal: ≤ 2–3 %	Higher purity required for high-quality industrial processes.
Poultry fat	Animal nutrition (feed, pet food)	Ideal: ≤ 10 %	Similar to tallow; low FFA prevents rancidity.
	Biofuels / energy	Ideal: ≤ 15 %	Same as tallow; a wider range of FFA is acceptable.
Pork fat (Choice white grease)	Animal nutrition (feed, pet food)	Ideal: ≤ 10 %	Maintaining low FFA is essential to preserve stability and nutritional value.
	Biofuels / energy	≤ 15 %	Can admit higher FFA, but requires pretreatment if levels are too high.
Yellow grease (mixed, recycled)	Biofuels / energy	Ideal: ≤ 15 % Acceptable: 15–20 %	Normally has high FFA; may require acidulation or neutralization.
Refined animal fats (refined tallow, bleached fats)	Cosmetics, pharmaceuticals, indirect human food use (additives)	≤ 0.5–1 %	Very low FFA required to avoid unwanted flavors, odors, and reactions.

Table of Typical Values. *Source: Codex Alimentarius, Bailey's Industrial Oil and Fat Products, USDA Agricultural Research Service.*

Although animal fats are usually evaluated for their stability and purity, animal meals are mainly valued for their nutritional contribution, especially their protein content.

QUALITY CONTROL ANALYSES ON ANIMAL MEALS

Before using an animal meal in a feed formulation or in the fertilizer market, it is essential to know what it actually contains. Composition analyses make it possible to determine the key nutritional values of the product. These parameters not only reveal the nutritional value of the meal, but also its stability and even allow assessing its overall quality.

AMINO ACID PROFILE:

This is the **equivalent of a fingerprint for animal meals**. Each protein is composed of a **specific combination of amino acids,** and this composition plays a **crucial role in animal nutrition**, since amino acids are the foundation of any formulation.

These analyses make it possible to:

1. Confirm the origin of the raw material.
2. Make optimal formulations for animal growth based on the amino acids present

MAIN AMINO ACIDS AND THEIR FUNCTIONS

Amino Acid	Main Function
Lysine	Promotes muscle growth, milk production, and enzyme synthesis
Methionine	Supports liver health, feather and hair synthesis, and acts as an antioxidant
Threonine	Essential for immunity and digestion (formation of intestinal mucosa)
Tryptophan	Regulates mood and appetite (serotonin precursor), important for well-being
Valine	Provides energy to muscles and supports metabolism
Leucine	Stimulates protein synthesis and muscle recovery
Isoleucine	Helps regulate blood sugar and repair tissues
Phenylalanine	Precursor of hormones and neurotransmitters (dopamine, adrenaline, etc.)
Histidine	Important for growth of young animals and formation of red blood cells
Arginine	Involved in reproduction, immunity, and wound healing

Table of Typical Values. *Source: Codex Alimentarius, Bailey's Industrial Oil and Fat Products, USDA Agricultural Research Service.*

PROTEIN:

This is possibly the very **first analysis required in the Rendering sector.** Protein is the main nutrient and the reason why rendering products such as animal meals have high value in various markets like animal nutrition and fertilizers.

This analysis makes it possible to:

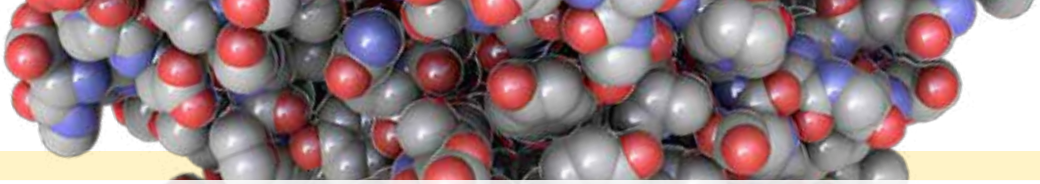
1. Evaluate the commercial value of a product.
2. Determine the protein richness of the meal.

Now that we have addressed the nutrients, let's talk about their value. Here, a central concept comes into play: ***DIGESTIBILITY.***

Digestibility tells us what portion of the nutrients is actually absorbed by the animal, and therefore what truly impacts its health, growth, and yield. It acts as an invisible filter between what we feed and what the animal really uses, and this principle will guide us throughout the entire analysis of animal meal quality.

Digestible Protein: This analysis quantifies the portion of protein that the animal can actually digest. A meal may contain a high amount of protein, but if the animal does not digest it well, it won't be used efficiently. This is why looking only at crude protein is not enough, digestible protein is analyzed as it represents the fraction that is truly absorbed and used by the animal.

Pepsin digestibility is a quick lab test used to gauge the protein quality of animal meals (meat, MBM, feather, fish) and to estimate how much protein monogastric animals can actually use. For example, feather and hog hair meals may exceed 80% crude protein, but their keratin-rich proteins are poorly digested, so digestible protein is low—limiting their nutritional value in feed formulas.



WHAT DOES THE PEPSIN DIGESTIBILITY TEST CONSIST OF?

- A sample of the meal is taken and incubated in an acidic solution with the enzyme pepsin (digestive enzyme present in the stomach of animals).
- Incubation is usually performed at pH 1.5–2.0 and 37 °C for 48 hours.
- Pepsin breaks down soluble proteins into shorter chains (peptides), as would occur in the stomach.
- The mixture is then filtered and the amount of nitrogenous matter (protein) digested/ dissolved by pepsin is determined.

INTERPRETATION OF THE RESULT (% DIGESTIBILITY)

- The result is expressed as the percentage of protein digested by pepsin relative to the total crude protein in the sample.
- Example: If a meal has 60% crude protein and 57% of that protein was solubilized by pepsin → digestibility = 95%.
- High values (≥90%) indicate good-quality proteins, properly processed and highly available to the animal.
- Low digestibility values (<80%) suggest overprocessing, poor-quality raw materials, or the presence of poorly soluble proteins (collagen, keratin).

WHAT DO VALUES LIKE 0.2, 0.02 OR 0.002 IN PEPSIN MEAN?

These values normally refer to the concentration of the pepsin solution used in the assay, expressed as percentage weight by weight (% w/w):

Pepsin	Technical meaning	Interpretation in results
0.2 %	Standard solution recommended in **hydrochloric acid** HCl 0.075 N	Allows consistent evaluation of the quality of animal-based meals; the most widely used for routine quality control.
0.02 %	10 times more diluted **concentration**	May underestimate digestibility, but helps detect more subtle variations among samples.
0.002 %	100 times more diluted **concentration**	Detects only proteins very sensitive to pepsin; commonly used in quality control in Latin American countries.

ASH:

Ash represents what remains once all organic matter has been burned: the mineral fraction, coming mainly from bones.

While useful in small amounts, if present in excess it can displace true nutrients, dilute protein, and slow down digestion.

In short, too much ash indicates a less nutritious meal.

But then, what are low-ash meals?

LOW-ASH MEALS

- This term refers to animal meals with reduced ash levels (typically <12–15%).
- This is achieved by selecting and processing by-products with less bone and more soft protein tissue (muscles, organs).
- In addition to selecting raw materials with lower bone content, there is the technological option of using a classifier (mechanical separator).

WHAT IS A MECHANICAL CLASSIFIER?

It is equipment that separates the solid fractions of the meal after the milling/rendering process, working through differences in particle size or density:

- Heavier particles (rich in bone/minerals) are separated.
- Lighter particles (rich in protein) are concentrated.

ADVANTAGES OF LOW-ASH MEALS

1. **Higher concentration of true protein:** with fewer minerals, the percentage of usable protein increases.
2. **Better digestibility:** excess ash reduces palatability and nutrient utilization.
3. **Higher value in premium pet food:** the pet food industry values meals with low ash content, as they provide more protein and less mineral residue.
4. **Greater nutritional consistency:** facilitates the formulation of diets with more stable amino acid profiles.

CALCIUM AND PHOSPHORUS:

The analysis of calcium and phosphorus, the **main trace minerals present in ash**, is very important. Fortunately, **not all ash is bad**: it also contains essential minerals such as calcium and phosphorus, which are indispensable for animal growth. They are desirable elements, as long as they are balanced and digestible.

An excess of calcium or an imbalanced calcium/phosphorus ratio could negatively affect feed quality.

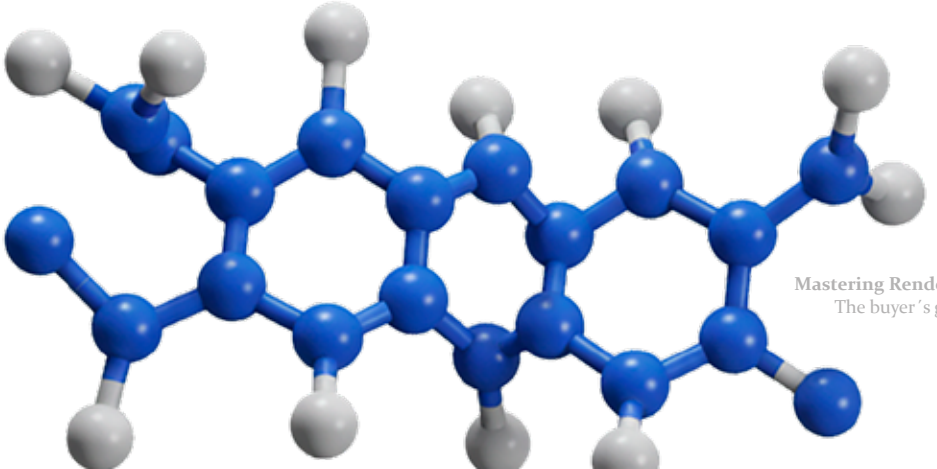
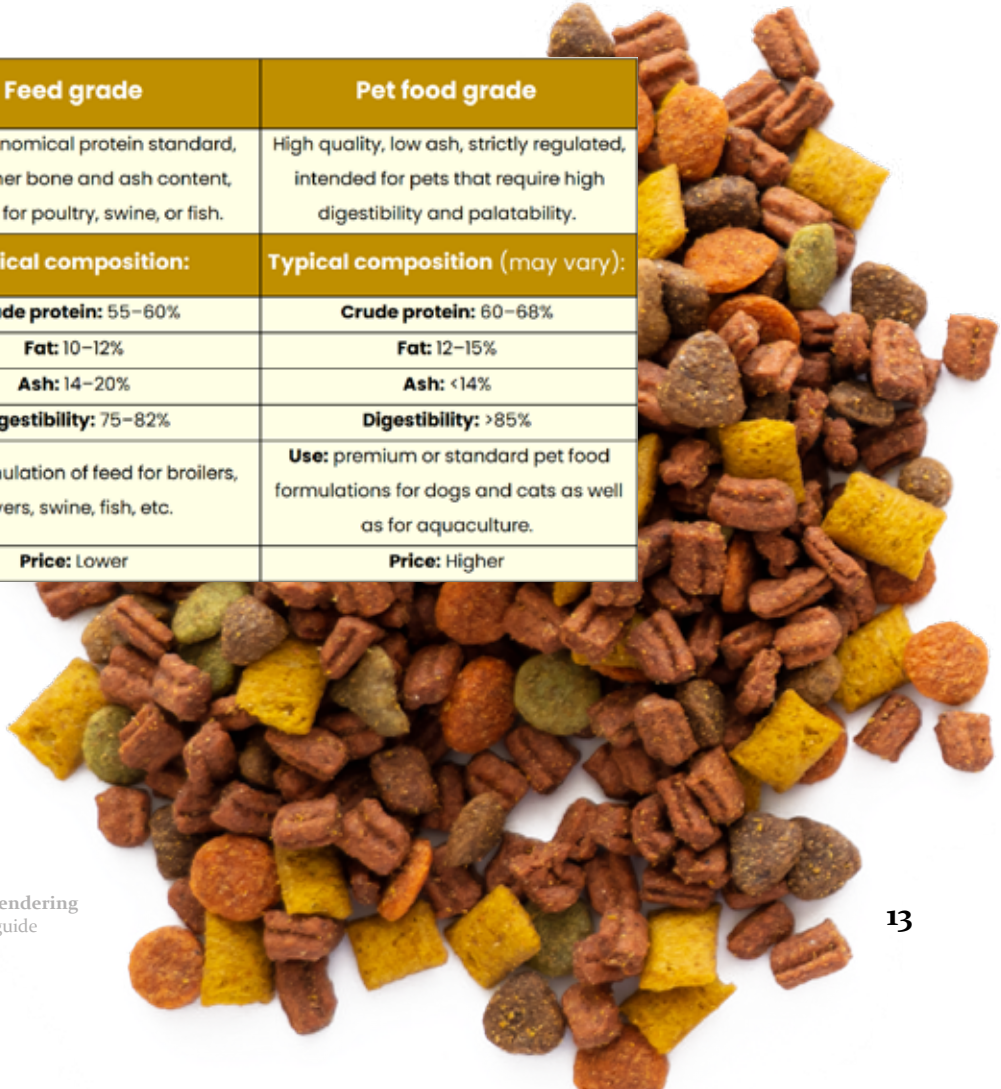


TABLE OF TYPICAL VALUES

Type of Meal	Protein (%)	Ash (%)	Digestibility (%)	Calcium (%)	Phosphorus (%)	Fat (%)	Moisture (%)
Meat and bone meal (bovine)	40–55	20–35	~78–92	5.0–10	2.5–5.0	8–12	≤ 10
Meat and bone meal (Swine)	45–60	15–25	~80–99	3.0–8.0	2.0–5.0	10–14	≤ 10
Fish Meal	60–72	15–25	~90–95	5.0–7.0	3.0–4.0	8–12	≤ 10
Poultry by-product meal (chicken)	60–68	14–22	~85–95	3.5–4.5	2.0–2.5	10–15	≤ 10
Turkey by-product meal	55–65	12–30	~82–90	3.0–5.0	2.0–2.5	8–12	≤ 10
Duck by-product meal	58–65	14–22	~82–90	3.0–4.5	2.0–2.5	10–15	≤ 10
Hydrolyzed feather/hair meal	70–85	<5	~50–65	<1	<1	5–10	≤ 10
Blood meal	80–90	<5	~80–90	<0.5	<0.5	≤3	≤ 8
Plasma meal	70–78	8–10	~95	<0.5	~0.2–0.4	1–2	≤ 7

At this point, it is vitally important to clarify the concept of poultry by-product meal in its two main qualities: pet food grade and feed grade, because although they may seem similar, there are critical differences in quality, regulation, and intended use.

Feed grade	Pet food grade
More economical protein standard, with higher bone and ash content, suitable for poultry, swine, or fish.	High quality, low ash, strictly regulated, intended for pets that require high digestibility and palatability.
Typical composition:	**Typical composition** (may vary):
Crude protein: 55–60%	**Crude protein:** 60–68%
Fat: 10–12%	**Fat:** 12–15%
Ash: 14–20%	**Ash:** <14%
Digestibility: 75–82%	**Digestibility:** >85%
Use: formulation of feed for broilers, layers, swine, fish, etc.	**Use:** premium or standard pet food formulations for dogs and cats as well as for aquaculture.
Price: Lower	**Price:** Higher



MOISTURE:
This analysis is fundamental in quality control, as it **quantifies the water content in animal meals.** Moisture can have several sources: it may be naturally **residual in the raw material or come from the cooking process, which can evaporate it to a greater or lesser extent.** The importance of this analysis lies in its impact on the durability, commercial value, and safety of the product.

Why Is Moisture Important?

Excess Moisture	Consequences
Promotes mold and bacterial growth	Health risk and quality loss
Reduces product stability	Lower shelf life, accelerated oxidation
Dilutes nutrient concentration	Proteins and minerals become less available
Distorts analysis results	Poor formulation, customer complaints

Two Products from the Same Process, but Two Very Different Quality Approaches!

Although both animal fats and animal meals come from the same transformation process, Rendering, their qualitative evaluation is based on different criteria. Their physical nature, composition, and especially their final use determine distinct quality control objectives.

- For animal fats, the main objective is to ensure the product's purity, stability over time, and thermal behavior, essential parameters to guarantee good preservation, efficient processing, and safe use in industry.
- For animal meals, on the other hand, the priority is their nutritional value, especially protein content and digestibility, since these characteristics directly affect animal feed formulation and expected nutritional performance.

Criterion	Animal Fat	Animal Meal
Physical form	Liquid	Solid
Key value sought	Purity, stability, thermal behavior	Protein content, digestibility
Main analyses	FFA, IV, SV, unsaponifiables, moisture, Impurities, MIU	Protein, amino acids, fat, moisture, ash, digestibility
Common defects	Impurities, water, oxidation, contaminants	Excess ash, low protein digestibility
Final use	Animal nutrition, biofuels, cosmetics	Animal nutrition, aquaculture, organic fertilizers

AND WHAT ABOUT CONTAMINANTS?

When we think of quality control, we often imagine complex analyses of proteins, ash, or fatty acids. However, there is a much more visible, yet equally critical, danger that can compromise a product: **physical contaminants.**

These very tangible intruders are among the most feared enemies of quality, both in animal fats and animal meals.

WHAT IS A PHYSICAL CONTAMINANT?

They are **foreign solid bodies** that **should never be present in an ingredient intended for animal feed or fertilizers**, such as:

- Pieces of plastic
- Remains of wood, rubber, or glass
- Metal fragments: nails, wires, nuts…
- Textile residues, stones, or even broken tools

They can come from:

- Misclassified or contaminated raw materials
- Contaminated transport (dirty trailers, cross-contamination)
- Or even worse: a mechanical failure in the processing plant that went unnoticed.

RISK TYPES AND CONSEQUENCES

Type of Risk	Possible Consequences
Animal safety	Internal injuries, digestive blockages, severe wounds
Equipment safety	Breakage of dosing, pressing, or extrusion equipment
Regulatory non-compliance	Product rejection, fines, loss of certifications
Commercial reputation	Loss of trust, customer claims, product discredit

GOOD NEWS!

Unlike certain chemical defects, **physical contaminants can be detected and removed… as long as the right tools are in place:**

- **Sieving:** simple but effective, to remove visible debris
- **Magnetic detection:** essential for ferrous metals
- **Enhanced visual inspection:** especially upon reception and after cooking
- **Gravimetric analyses:** to quantify insoluble impurities

In short, a product may be perfect on paper, stable, rich in protein, well processed, but if it contains a piece of plastic, a bit of wire, or a fallen screw, it becomes immediately unusable and even dangerous. Controlling physical contaminants is the first line of defense to ensure safety, protect equipment, comply with regulations, and maintain customer trust.

QUALITY CONTROL: TWO STAGES, ONE MISSION!

Talking about quality control often evokes the image of scientists with complex instruments in hand, rigorously analyzing a sample of meal or fat.
And it's true — the laboratory plays an essential role in the final validation of a product.
But quality does not start or end there. **The most efficient companies know this well: quality is built long before the lab, from sourcing to sales, and is maintained continuously, directly in production.**

FIRST STAGE: THE LABORATORY, GUARDIAN OF QUALITY

The laboratory acts as the final filter before releasing a batch: it confirms quality through rigorous analyses, ensures traceability, and provides evidence in the event of audits or complaints.
Main functions:

- Nutritional and chemical analyses (proteins, moisture, ash, fatty acids…)
- Safety tests (contaminants, pathogens, stability)
- Verification of customer specifications (digestibility, MIU, amino acid profile…)

These results are crucial to:

- Ensure traceability
- Guarantee regulatory compliance
- Provide objective proof of quality

However, there is one limitation: these analyses intervene after a problem has occurred.
They diagnose… but they do not prevent.

SECOND STAGE: QUALITY CONTROL IN PRODUCTION, A PREVENTION TOOL

It is on the ground, in the heart of production, where quality is truly built every day. Here, it's no longer about test tubes or chromatographs, but about:

- Visual checks of raw materials
- Verification of cooking temperatures and times
- Monitoring of homogeneity, color, and texture
- Control of visible impurities
- Systematic sampling and real-time documentation
- Real-time alarms on critical equipment

These simple, repeated actions allow teams to:

- Act immediately in the event of any deviation
- Prevent quality drifts
- Reduce losses or batch rejections

The modern vision of quality control is no longer about finding defects at the end, but about preventing them from the very beginning. This implies:

- Training operators to detect deviations
- Documenting actions during production
- Facilitating communication between plant staff and the laboratory

By integrating **both stages**, the **precision of the laboratory** and the **vigilance of production,** companies can achieve a product that is **stable, compliant, and of high value in every batch.**

NIR: THE DIGITAL EYE OF CONTINUOUS QUALITY CONTROL

While laboratory analyses offer unmatched precision, they have one major drawback: **time**. In continuous production, every minute counts. That's where **(NIR)** comes into play, **a true technological revolution in online quality management.**

NIR (Near Infrared Reflectance) **is a technology based on the reflection of near-infrared light, which allows measuring multiple physicochemical parameters of a product in real time, without the need for sampling or interrupting production**. Installed above a screw conveyor or belt, it can continuously analyze the material passing underneath.

To understand how NIR analyzes quality in real time, imagine it as a **specialized camera**: instead of capturing visible images, it captures **"light fingerprints" invisible to the human** eye in the near-infrared range.

When infrared light is projected onto a sample (such as meal or fat), part of it is absorbed and part is reflected. **This reflection is unique, like a chemical photo of the product.**

WHAT MAKES NIR SO SMART IS ITS INTERNAL LIBRARY:

it compares each "photo" it captures with thousands of reference images it has previously learned (this is called calibration).

Thanks to this, **it can deliver results for moisture, ash, protein, and fat in just a few seconds.**

In other words, **NIR turns quality control into a proactive steering system:**

- Enables **immediate reaction to any deviation** (e.g. high moisture, low protein).
- **Reduces reliance on the laboratory,** improving batch consistency.
- **Feeds quality dashboards** useful for audits, process adjustments, and traceability.