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OXIDATION

OXIDATION, OXIDANTS AND ANTIOXIDANTS IN LAYER NUTRITION

ENG

Oxidation is one of the most common (Frankel, 2005) but least recognized reasons for poor performance in commercial layer flocks.

It silently destroys the quality of fats, oils, grains, proteins, vitamins, and finished feed during storage, transport, and feed milling.

Even when diets appear normal, oxidized ingredients can reduce energy value, damage nutrients, create toxic by-products, and impair the health and productivity of laying hens.

Many unexplained issues, such as pale yolks, poor shells, lower egg numbers, wet droppings, variable feed intake, weak flock uniformity, and increased susceptibility to heat or disease, are often linked to oxidation in feed and oils.

This document provides practical, simple guidance to help feed millers and farmers understand oxidation, identify it early, evaluate risks, and use antioxidants effectively to protect feed quality and flock performance.

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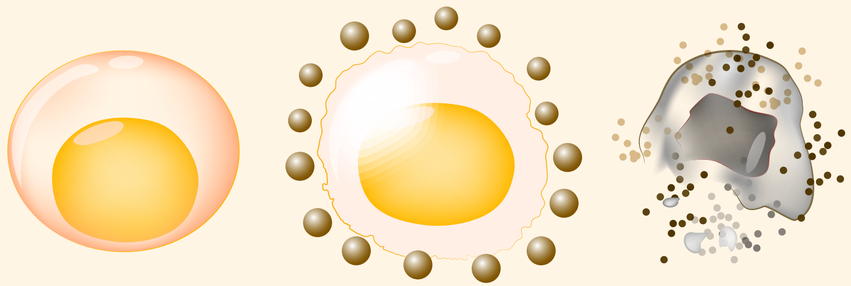
What is Oxidation?

Oxidation is a chemical reaction in which oxygen attacks fats, oils, vitamins, proteins, and pigments (Frankel, 2005; Oke et al., 2024).

When unsaturated fatty acids in oils react with oxygen, they form unstable molecules called hydroperoxides.

These quickly break down into aldehydes, ketones, and other harmful compounds. This entire process is known as lipid peroxidation (Surai, 2002).



In poultry nutrition, oxidation is especially important because oils and fats supply high energy and contain polyunsaturated fatty acids (PUFA), which spoil quickly.

Oxidation happens in three steps: initiation (formation of the first free radicals), propagation (rapid chain reaction that damages nutrients), and termination (final breakdown products). By the time the reaction reaches the termination stage, most damage has already occurred.

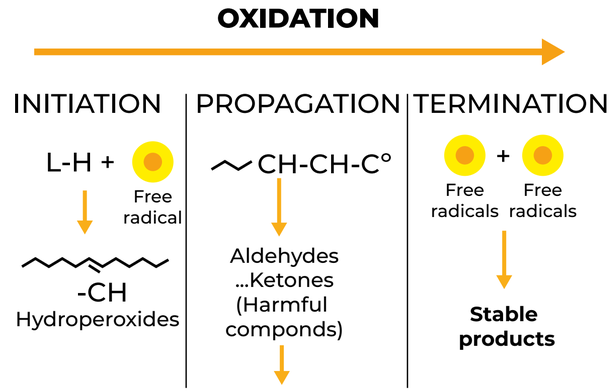


Figure 1. *Oxidation process and stages; L–H represents a lipid molecule (L) with a hydrogen atom (H) attached. During the initiation phase of oxidation, heat, light, or metal ions remove this hydrogen atom, converting the lipid (L–H) into a lipid radical (L·). This unstable radical is what triggers the entire oxidation chain reaction.*

What Causes Oxidation in Feed and Oils?

Several factors are responsible for the initiation of lipid oxidation some are list below (Durand et al., 2024)

1 High PUFA Content

Soybean oil, canola oil, fish oil, and poultry fat contain many double bonds that oxidize easily. The more PUFA present, the higher the risk.

2 Heat, Light, and Humidity

High temperatures in feed mills, storage tanks, or farm bins speed up oxidation. Sunlight and UV exposure also break down fats rapidly. Humidity increases mold growth and enzyme activity that accelerates oxidation.

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3 Exposure to Oxygen/air

Open tanks, leaky valves, poorly sealed containers, and high surface area exposure allow oxygen to continuously enter, fuelling the reaction.

4 Metals and Equipment Contamination

Iron and copper residues—from pipelines, tanks, pumps, and grinding equipment—are powerful catalysts that dramatically increase oxidation rates.

5 Poor Quality or Recycled Oils

Used cooking oils, dark-colored oils, oils with high free fatty acids (FFA), or oils with impurities oxidize much faster and are unsafe for poultry.

6 Enzymes in Grains

Certain grains (especially soybeans and wheat) contain natural lipoxygenase enzymes that start oxidation during storage or processing (Axelrod & Laakso, 1981; Mihaljevic, 1996)

▲ ***Figure 2.*** *Factors affecting rate of oxidation in oils/fats*

How to Identify Oxidized Materials (Practical Field Guide)

Farmers and feed millers can identify oxidized feed without lab equipment using simple sensory observations.

Feed Material	Fresh (Good Quality)	Oxidized (Bad Quality)
Oils & Fats	· Light color (yellow/ golden) · Clear and flows smoothly · Mild, pleasant smell	· Dark yellow to brown · Thick, sticky, or cloudy · Strong sharp smell (paint, varnish, metallic, burnt)
Corn & Grains	· Bright, clean kernels · Natural grain smell	· Dull, dusty, faded color · Musty or sour odor · Clumping or oily patches
Soybean Meal	· Golden-tan color · Mild aroma · Uniform appearance	· Darker brown · Sharp or chemical smell · Uneven, discolored texture
DDGS	· Amber color · Uniform texture · Slight sweet smell	· Dark brown · Burnt or smoky odor · Lumpy from heat damage
Pelleted Feed	· Smooth, firm pellets · Mild cereal smell · Little dust	· Dusty, crumbly pellets · Greasy or sticky surface · Strong rancid odor
Vitamin Premixes	· Bright and uniform color · Free-flowing powder	· Brownish or dull color · Clumping or moisture lumps · Burnt or chemical smell

If something looks dark, smells sharp or sour, feels sticky, or forms lumps — it is likely oxidized and should NOT be used

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Why Oxidation Matters: Impact on Feed Quality and Nutrients

1 Loss of Energy

Oxidized oils lose approximately 8–15% (Baiao and Lara, 2005) of their metabolizable energy (ME). Layers eating oxidized oil consume more feed but gain less energy, reducing production efficiency.

2 Vitamin Destruction

Fat-soluble vitamins (A, D3, E, K) degrade rapidly in oxidized feed. In severe cases, losses reach 80–100%. This weakens immunity, bone health, pigmentation, and shell quality.

3 Loss of Carotenoids

Carotenoids responsible for yolk color degrade quickly, leading to pale yolks and poor pigmentation.

4 Protein Damage

Heat and oxidation, ie.: DDGS or soybean meal, and pelleted feeds reduce amino acid digestibility and increase indigestible fractions.

Impact of Oxidized Feed on Laying Hens

Reduced Feed Intake

Birds naturally avoid rancid odors. This may lead to compromised feed intake that alternatively could impact body weight gain, flock uniformity during rearing period.

Drop in Egg Production

Oxidized feed reduces laying rate by 2–8% due to reduced energy, damaged nutrients, and stress on the reproductive system (Yue et al., 2011, Saki at al., 2016; Oke et al., 2024).

Poor Egg Quality (Varastegani & Dahlan, 2014, Saki et al., 2016)

Layers fed oxidized feed show:

- Lower egg weight
- Pale yolks
- Weak shells (10–15% reduction)
- Faster yolk rancidity during storage

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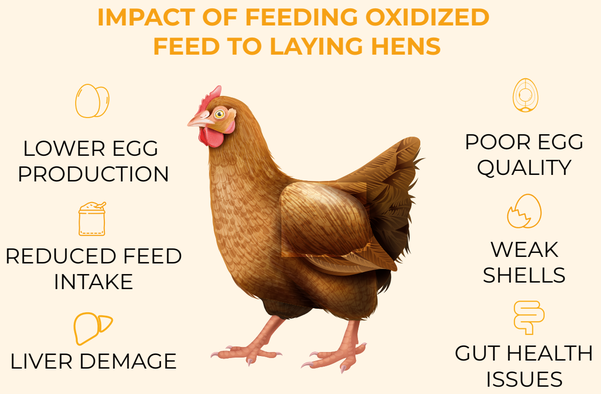
Liver Stress

The liver must detoxify aldehydes and peroxides, leading to fatty liver changes, reduced metabolism, and increased mortality risk (Zhou et al., 2020; Oke et al., 2024).

Increased Oxidative Stress

Markers such as malondialdehyde (MDA) and TBARS increase, while natural antioxidant enzymes decrease. Birds become more vulnerable to heat stress, disease, and mycotoxins (Oke et al., 2024; Petcu et al., 2023).



▲ ***Figure 3.*** *Impact of feeding oxidized feed in laying hens*

How Feed Mills Can Measure Oxidation

There are a number of analytical methods available in the industry to measure the extent of oxidation in fat/oils and other ingredients (Abeyrathne & Ahn 2021; Kemin Industries, 2022)

1 Peroxide Value (PV)

Indicates early-stage oxidation (hydroperoxides).

Recommended: < 5 meq/kg

2 p-Anisidine Value (AV)

Measures aldehydes formed in the later stage.

3 TOTOX Value

Total oxidation (TOTOX = 2 × PV + AV).

A good overall indicator of spoilage.

4 TBARS

Measures MDA, useful for assessing oxidation in finished feed or tissues.

5 OSI/Rancimat

Used to determine the stability and shelf-life of oils.

Routine testing helps prevent field problems before they affect flocks.

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Using Antioxidants in Oils and Feed

How Antioxidants Work

Antioxidants protect oils and feeds by:

- ✔ Neutralizing free radicals
- ✔ Stabilizing hydroperoxides
- ✔ Protecting vitamins and pigments
- ✔ Maintaining ME value

Types of Antioxidants

Synthetic Antioxidants

- BHT
- BHA
- TBHQ
- Ethoxyquin

Natural Antioxidants

- Tocopherols
- Rosemary extract
- Green tea extracts
- Ascorbyl palmitate

Choosing the Right Antioxidant

Selection should be based on composition, stability, application need (oil vs feed), and cost-effectiveness. Antioxidant blends often give the strongest protection.

MOST COMMON PARAMETERS for MEASURING OXIDATION RATE

AV	Aniside Value	PV	Peroxide Value	TOTOX	TOTOX Value

Aldehydes formed later in oxidation	Early-stage oxidation (hydro-peroxides)	Total oxidation (2xPV+AV)
Permisible level:	Permisible level:	Permisible level:
<8	<5 meq/Kg	<20

Explanation of Graphic

Testing methods to monitor the extent of oxidation | Safe limits for measuring rancidity in oils and fats

▲ ***Figure 4.*** *Steps to protect oil/fats from oxidation and types of antioxidants*

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Conclusion

- Oxidation is one of the most important—and preventable—factors affecting feed quality and layer performance.
- It reduces nutrient value, destroys vitamins, lowers ME, harms egg production and egg quality, and causes oxidative stress and liver damage in hens.
- By identifying oxidation early, applying correct handling and storage practices, and using the right antioxidant solutions, feed mills and farmers can protect feed quality, improve flock health, maintain consistent egg numbers, and enhance profitability.
- Controlling oxidation is a simple, cost-effective strategy that supports strong, sustained performance in modern layer operations.

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