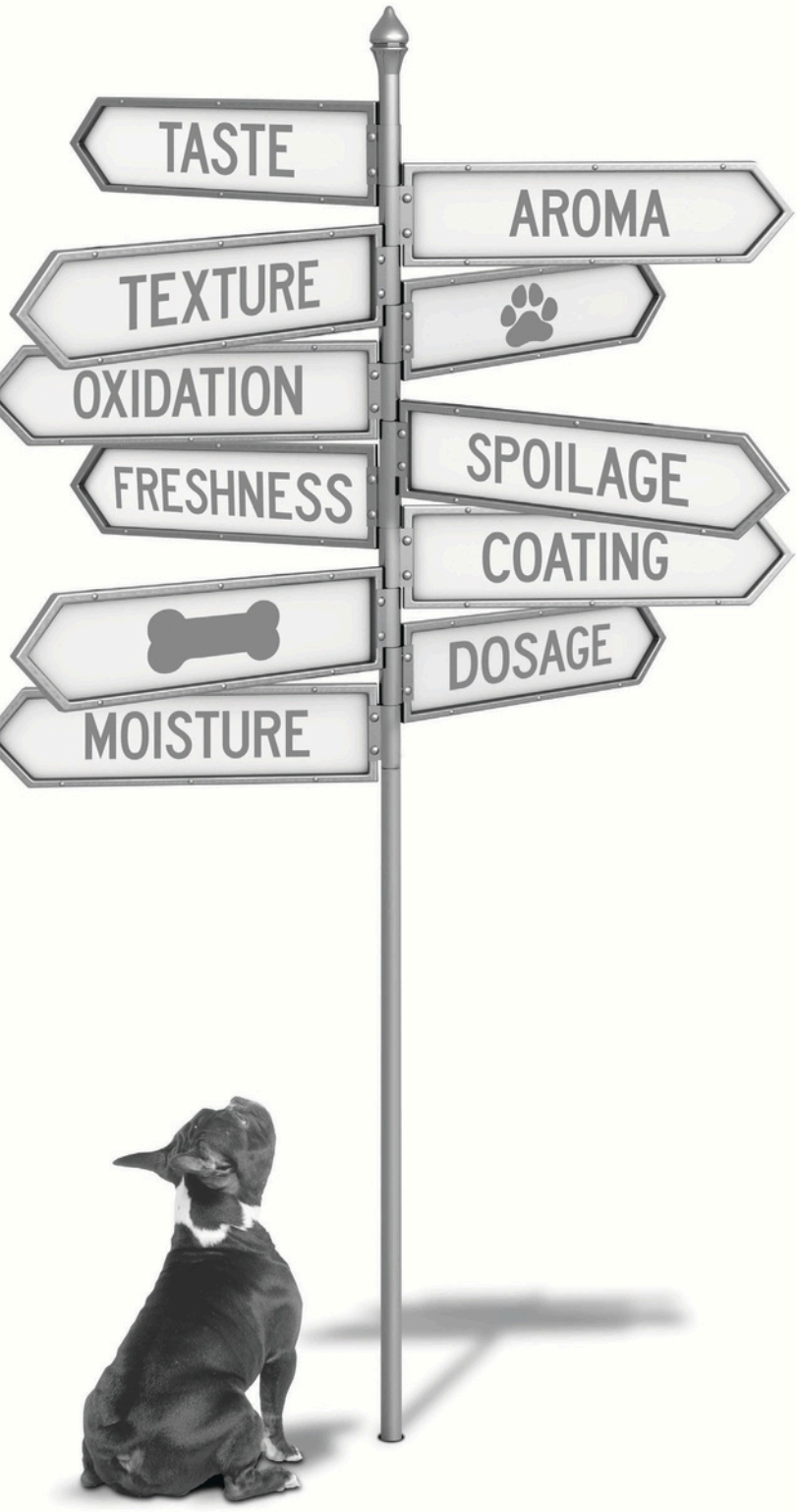


Oxidation in Pet Food Palatability

Ensuring adequate shelf life is a complicated challenge that pet food manufacturers face every day. A pet food manufacturer can ensure that their raw materials and finished products are adequately stabilized and in appropriate packaging, but there are still other factors that challenge stability and shelf life once the package leaves a warehouse.

PALASURANCE®

KEMIN®
Compelled by Curiosity™

The Shelf Life Challenge

One of the main challenges of shelf life is how pet owners store pet food and treats in their homes. Some scenarios to consider:

- Pet food is introduced to oxygen and moisture every time a bag is opened to feed a pet.
- Pet owners can be enticed, by prices, into purchasing more pet food than their small pet can eat in a reasonable period of time. This can mean that it could take several months after the bag is opened for the food to be consumed.
- Pet food packaging often includes specially designed barriers that are designed to protect the diet from oxygen and moisture. However, the food is often transferred to other storage containers that do not offer any protection from the elements.
- Food may be stored in a garage or shed, with exposure to fluctuations in temperature and moisture. High temperatures and moisture can rapidly decrease the quality of the food.

Even if poor storage of pet food isn't the pet food manufacturers fault, they will still receive the blame from consumers for storage related issues. No one wants to receive customer complaints for things such the diet being stale, foul smelling, oxidized, or moldy. **All of these complaints can be prevented or controlled with proper antioxidant and microbial control products.**

The Effect of Pet Food Trends

Further complicating the challenges of shelf life is the growth of natural, organic, and novel ingredients pet food trends.

In response to these trends, pet food diets have seen an increased usage of unsaturated fats and oils. **Unsaturated oils are more prone to lipid oxidation than saturated fats.** For example, a diet high in fish and vegetable oil that uses brown rice instead of corn will have a fatty acid composition that is much more prone to oxidation than a traditional chicken, poultry fat and corn-based diet.

Trends such as raw, frozen, semi-moist, freeze-dried and high meat diets pose unique stability challenges and complexity. Many of these trends and ingredients requires customized solutions. There are no one-size-fits-all antioxidant solution that works for all diet types.

Lipid Oxidation, Explained

Lipid oxidation is a degradation reaction of lipids. The process of lipid oxidation is fairly complex, but it can be divided into three different phases:

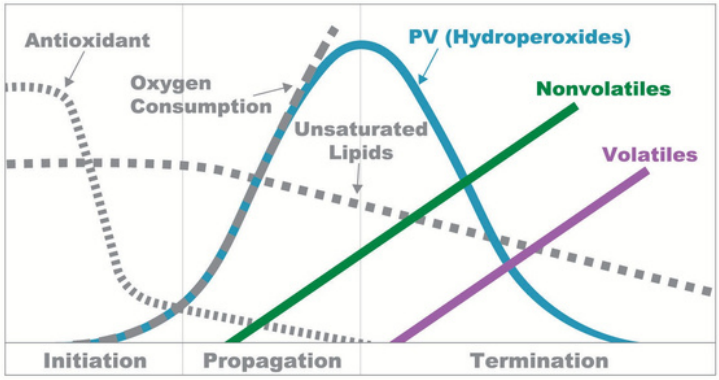
Initiation • Propagation • Termination

During the initiation phase, oxygen reacts with initiators, such as light, metals, or enzymes to form free radicals. These radicals then react with unsaturated fats to create peroxy radicals, hydroperoxides, and secondary products, such as aldehydes.

During the propagation phase, radicals react with non-radicals to form new radicals. This process that repeats over and over is referred to as a chain reaction mechanism. During this phase, the radicals accumulate and can be observed from increases in the peroxide value and changes in the odor, which is often quantified from the measurement of aldehydes.

The termination phase is the point where termination reactions are occurring more often than propagation reactions. This late oxidation phase coincides with high concentrations of radicals. At this stage, the amount of unsaturated fatty acids that haven't oxidized has been greatly reduced. During this phase, the peroxide value is often found to decrease along with a reduction in unsaturated fatty acids. Aldehydes and polymers are typically seen to increase. Late stage oxidation signs include increased viscosity, along with high levels of a paint-like odor.

Figure 1. Lipid Oxidation[1]



Meats, protein meals, oils and fats, are all examples of raw materials that contain unsaturated fats and which can undergo lipid oxidation reactions. In the manufacturing of pet food and treats, these susceptible components are exposed to a variety of factors that can impact oxidation.

Factors that impact oxidation include:

- Thermal processes (extrusion, drying, retort, rendering, and freeze/thaw cycles)
- Packaging (exposure to atmospheric oxygen)
- Product formulation
- Raw material quality

Lipid Oxidation Reaction Rates

Lipids are often characterized by their degree of unsaturation (the number of double bonds in a fatty acid). For example, soybean oil, which is liquid at room temperature, has a higher degree of unsaturation than butter, which is solid at room temperature. The rate of lipid oxidation depends on the degree of unsaturation. A high degree of unsaturation can result in an exponential increase in the rate of lipid oxidation, see Table 1.

Table 1. Lipid Oxidation Reaction Rates[2]

Fatty Acids	Relative Rates
18:1 n9	1
18:2 n6	50
18:3 n3	100
18:4 n3, 20:4 n6	150
20:5 n3 (EPA)	200
22:6 n3 (DHA)	250

Lipid Oxidation and Food Quality

Lipid oxidation can have a significant effect on food quality. Color, nutrition, quality, odor, palatability and taste can all be impacted by lipid oxidation. **The most common measurement for lipid oxidation is the Peroxide Value (PV) test.**

The PV test measures hydroperoxides which are quickly formed after the hydrogen is abstracted from the lipid. Hydroperoxides are odorless and tasteless, so these are not the compounds that people think of when they smell or taste an oxidized food. Hydroperoxides are also transitional compounds and readily decompose.

During the decomposition process, secondary compounds are formed. The aldehydes that are formed produce the classic odor and flavor changes that are the classic signs of lipid oxidation. These aldehydes are formed during the termination phase. Many of these aldehydes can be detected at very low concentrations. Table 2 shows examples of human flavor threshold concentrations for some common aldehydes.

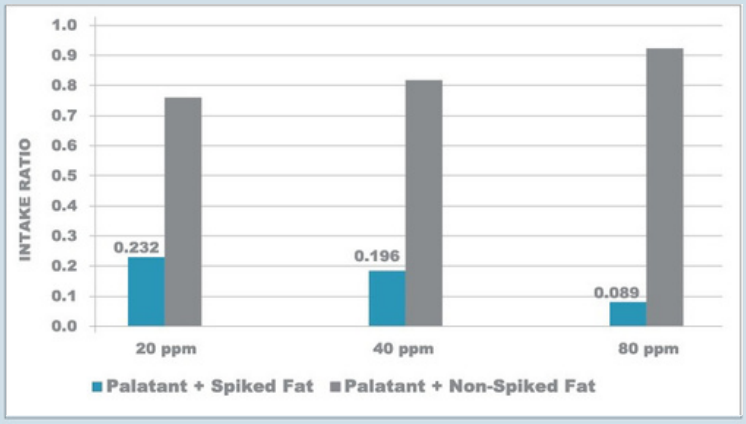
Table 2. Human Flavor Threshold Concentrations for Common Aldehydes[3]

Aldehyde	Human Flavor Threshold (ppm)
2-Decenal	5.5
2-Undecenal	4.2
2-Octenal	1
2-Heptenal	0.63
Nonanal	0.32
2,4-Decadienal	0.28
Hexanal	0.15
2-Nonenal	0.1
Octanal	0.068
Heptanal	0.042

Oxidation Effects on Palatability

Pets are even more sensitive to aroma than humans, so their flavor thresholds are even lower. Figure 2 shows dogs' sensitivity to aldehydes. In this case, pet food was top coated normally with a palatant and a fresh fat with very low levels of PV's and aldehydes. Then the fat was spiked with 20, 40, and 80 ppm of a 50:50 mixture of hexanal and 2,4-decadienal. The following chart shows how these aldehyde spikes affected dogs' choice in a palatability trial at a third-party kennel. Figure 2 shows lipid oxidation can have a large impact on a dog's food choice.

Figure 2. Palatability of Fat Spiked with Secondary Aldehydes[4]



Controlling Lipid Oxidation in Pet Food with Antioxidants

Aldehydes have a wide range of odors. Some aldehydes have a sweet and pleasant smell, while others have off odors that most people would not consider pleasant smelling. Hexanal has a grassy odor, and 2,4-decadienal has a burnt deep-fried odor. Most of the aldehydes that are formed from lipid oxidation reactions have off odors.

The key to controlling the formation of the aldehydes is to prevent or delay oxidation from occurring in the first place. Once the propagation phase begins, it's typically too late to control oxidation. Antioxidants are key to the prevention of the aldehyde formation.

Antioxidants are defined as substances that are active in the prevention or delaying the oxidation of a food material. Antioxidant mechanisms vary depending on the antioxidant. Various mechanisms can include breaking or interrupting free radical chains or inhibiting the formation of hydroperoxides. Other compounds can support antioxidant efficacy such as metal chelators which inactive metals and prevent metal catalyzed initiation and decomposition reactions.

Not only is it important to understand the type, solubility and mechanism by which an antioxidant of choice prevents oxidation, but also the point at which an antioxidant is added in the pet food manufacturing process. Depending on the application, antioxidant may be applied to an animal-based raw material prior to rendering, at storage loadout and fat cleanup at a rendering facility, to a meat slurry before transport to a pet food facility, to a kibble or treat dry mix, and/or before being exposed to any heat, such as grinding, mixing or extrusion. It is important to partner with an antioxidant supplier who understands how to utilize antioxidants throughout the complex pet food supply chain and manufacturing process.

In conclusion, lipid oxidation is a complex process that can have a big impact upon the quality of a food matrix. Once oxidation occurs, termination reactions generate aldehydes which will have a detrimental impact upon the palatability of the food matrix. The use of antioxidants is key to controlling oxidation reactions and maintaining flavor in the finished pet food diet.

Color, nutrition, quality, odor, palatability and taste can all be impacted by lipid oxidation.

OXIDATION AND PET FOOD PALATABILITY

Key Takeaways

- Ensuring adequate shelf life is a complicated challenge that pet food manufacturers face every day
- Lipid oxidation is a degradation reaction of lipids, including common pet food ingredients such as meats, protein meals, oils and fats
- Many factors impact oxidation, such as thermal processes, packaging, product formulation and raw material quality
- Lipid oxidation can have a significant effect of color, nutrition quality, odor, palatability and taste
- It is important to partner with a supplier who understand how to utilize antioxidants through the complex pet food supply chain and manufacturing process to maintain diet stability and palatability

References
1. Lubuza, T. P. Kinetics of Lipid Oxidation in Foods, CRC Crit. Rev. Food Technol. 1971. 2, 355-405
2. Lipid Oxidation, Second Edition, E. N. Frankel. The Oily Press, Bridgwater, England, 2005
3. Frankel, E. N. (1984) "Recent advances in the chemistry of rancidity of fats", Spec. Pub. R. Soc. Chem. (47) 87-118
4. Kemin Internal Document: SD-17-00022
Images: Shutterstock.