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Lipid peroxidation measurements require multiple assays

ADDING feed-grade lipid sources to swine diets is a widespread practice within the industry as a concentrated source of calories.

Lipid quality can degrade during storage and processing at a quicker rate than is normal with other raw materials. However, fat quality measurement is variable within the industry, leading to uncertainty regarding the most accurate way to measure and manage fat quality to predict the optimal animal response.

Multiple measurements are available that can be utilized to evaluate the oxidative quality of a given fat source; however, the primary metrics utilized include assays that identify the quantity of different peroxidation compounds.

Lipid peroxidation is a complex process that involves multiple chemical reactions and encompasses many compounds. The initial products produced include lipid hydroperoxides and are quantified by the peroxide value (PV) assay. The PV assay is a common metric used partially due to its low cost. These initial compounds alone have effects on lipid quality; however, the hydroperoxides also serve as precursors for further degradation into secondary peroxidation compounds. Additionally, free radicals are generated from hydroperoxides, which lead to an accelerating chain reaction of lipid degradation.

Other assays such as p-Anisidine value (AnV) and thiobarbituric acid reactive substances (TBARS) quantify the presence of secondary peroxidation compounds. AnV quantifies the presence of aldehydes, and TBARS quantifies the presence of malondialdehyde and other carbonyl compounds. There are additional assays that measure even more exact peroxidation compounds. From a cost standpoint, however, those assays are only applicable to experimental conditions.

The degree of peroxidation a lipid can undergo is influenced by multiple factors, including, but not limited to, the degree of saturation, presence of oxygen, transition metals, humidity, antioxidant content and temperature.

To evaluate temperature and oxidative exposure, DeRouchey et al. (2004) conducted a study in which choice white grease (CWG) was heated to 80°C for up to 11 days in the presence of oxygen gas. The researchers observed increases in PV of the fat source up until day 7 (105 mEq/kg lipid), and then PV subsequently decreased back to the baseline levels of the untreated CWG. This confirms that hydroperoxides are generated to some level and then will be utilized to produce secondary peroxide components.

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Bottom Line

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The researchers also evaluated AnV and observed similar responses to PV, with the values increasing through day 7 of exposure. Thereafter, AnV began to decrease back towards the untreated CWG values, but to a much lesser extent than PV (Figure).

Subsequently, DeRouchey et al. utilized these samples in a feeding trial with young pigs and observed linear decreases in average daily gain (ADG) and average daily feed intake (ADFI) as CWG was exposed to increasing degrees of thermal and oxidative exposure. This would suggest that PV and AnV didn't fully capture the degree of peroxidation.

A similar evaluation with multiple lipid sources was conducted by Liu et al. (2014a) in which they utilized several additional assays. These researchers observed results comparable to those of DeRouchey et al. (2004) regarding PV. The PV responses were of greater magnitude in corn and canola oil samples than in poultry fat and tallow samples. This would make logical sense, since vegetable oils have a greater concentration of polyunsaturated fatty acids that, therefore, would be susceptible to peroxidation.

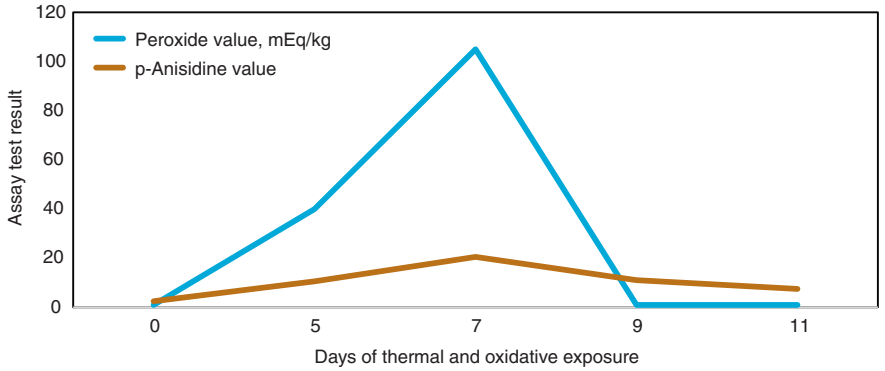
For the animal fat sources, Liu et al. observed a similar response in AnV to DeRouchey et al., but the vegetable oils maintained continuous increases in AnV when exposed to greater oxidative conditions.

To illustrate the effect of feeding peroxidized fat on animal performance, Hanson (2014) summarized 16 studies and showed that pigs fed iso-caloric diets containing peroxidized lipids relative to those containing unperoxidized lipids had reductions of 11.4% in ADG and 8.8% in ADFI. Hanson did not see a correlation between ADG and PV in those studies. The lack of correlation is primarily based on a low PV (less than 5.0 mEq/kg of diet) being representative of a lipid source that has undergone either no peroxidation or heavy peroxidation. Hanson did demonstrate a negative correlation ($r = -0.63$, $P = 0.05$) between ADG and dietary TBARS concentration.

As a point of reference, visual analysis of the correlation graph suggests that feeding a dietary TBARS concentration of 5.0 mg of malondialdehyde equivalents per kilogram of diet yields approximately 85% growth response, as expected from feeding a diet without peroxidized lipids. Hanson suggested that TBARS is a more valuable metric for estimating quality. However, there are no generally accepted standards for what numerical value represents a maximum threshold for TBARS.

Growth performance is not the only metric that has been evaluated in relation to feeding peroxidized lipids. DeRouchey et al. (2004) demonstrated that

Impact of thermal and oxidative exposure on peroxidation compound levels



Source: Adapted from DeRouchey et al. (2004).

feeding peroxidized CWG had no impact on the digestibility of total lipids or fatty acids.

Additionally, several studies, including Liu et al. (2014b), have indicated that feeding peroxidized lipids can have a negative effect on the oxidative status of pigs. While there are clearly measurable whole-body impacts of feeding oxidized lipids, from a production standpoint, it is clear that ADFI and, subsequently, gain are affected when feeding oxidized lipid sources.

Antioxidant technologies are valuable tools that offer protection against peroxidation only when added prior to exposure to peroxidation conditions. There are limits to which the antioxidant's protective functions can be overcome, however. Understanding the source of the lipid and associated risks (raw material source, fatty acid profile, exposure conditions, moisture content, etc.) within that source are import factors in determining whether an antioxidant is necessary for a given source.

The Bottom Line

Utilizing dietary lipids that contain peroxidation compounds has a detrimental effect on the growth performance and oxidative status of pigs. By utilizing only PV at a single time point as an estimate of lipid quality, there is the potential that the value will not fully quantify the level of peroxidation, particularly if the lipid was exposed to harsh processing conditions.

While a high dietary PV would indicate peroxidation, a low dietary PV (less than 5.0 mEq/kg of diet) does not necessarily indicate that the lipid content has not undergone peroxidation and could represent a diet containing lipids that have undergone extreme peroxidation.

To fully estimate the level of peroxidation, multiple assay measurements are necessary. Currently, there are no generally accepted standards for peroxidation and additional research is necessary to set acceptable limits for metrics such as TBARS.

References

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