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Evaluation of the Variability in Oxidative Status of Fats and Oils used in Livestock and Poultry Diets in North America

Introduction

Fat and oils – or lipids – are an essential energy source in nearly every animal's diet. However, lipid sources used in feed formulations today – animal fats, vegetable oils, blended fats and by-product oils – are not all created equal. Variability in the physical and chemical properties of lipids can impact digestibility as well as lipid susceptibility to oxidation – a major source of decreased lipid quality.

Oxidation is an irreversible process in which fatty acids and fat-soluble vitamins are degraded, thereby reducing the energy supply and nutritional quality of the diet. Fat oxidation increases the presence of toxic compounds such as free radicals, peroxides and aldehydes which can reduce feed palatability as well as lead to oxidative stress, which negatively impacts overall livestock and poultry performance.[1-6] Therefore, it is important for producers and nutritionists to understand and properly evaluate the quality and nutritional value of lipids, including their oxidative status and potential for oxidation, when formulating dietary rations.

To help nutritionists better understand how oxidation may impact their lipid quality, the Kemin Customer Laboratory Services (CLS) lab offers customers the ability to analyze their fat and oil samples for select oxidative parameters. Analysis of oxidative markers allows for estimations of the current degree of oxidation and the potential for future oxidation of a lipid sample. Over the years, a large variability in oxidative parameters has been noted in supplemental animal fats and vegetable oils used in livestock and poultry diets.[7,8] The purpose of this report is to summarize the results of all lipid samples (n=392) analyzed by Kemin CLS for oxidation markers from January 2018 through September 2020.[9]

Materials and Methods

Fat and Oil Sample Profile

Between January 2018 and September 2020, 392 fat and oil samples were submitted to Kemin CLS for oxidation marker and oxidative stability testing (Figure 1). Vegetable oils, animal fats and blended fat made up 56%, 36% and 8% of samples, respectively. The three most common fat and oil types submitted were corn oil (31%), choice white grease (CWG, 26%) and soybean oil (17%). Samples labeled as tallow, poultry fat, animal fat, bacon grease and yellow grease were grouped into "other animal fat" (10%). Other vegetable oils (8%) included canola oil, sunflower oil, oil and vegetable oil. Blended fats (8%) included samples labeled as animal vegetable (AV) blends, blended fats and generic fat.

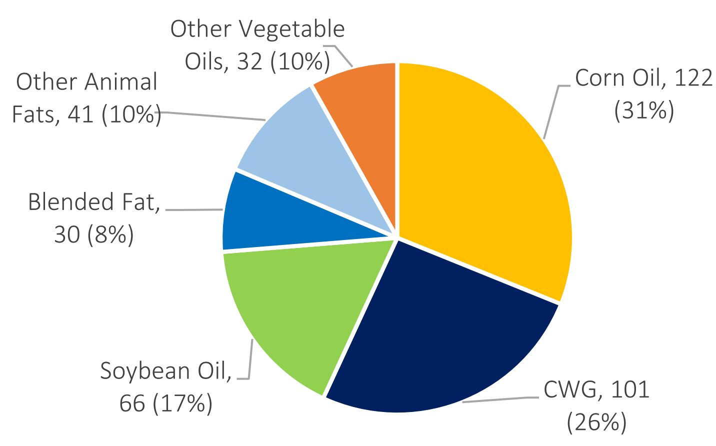

Figure 1. Fat and oil samples analyzed by Kemin CLS from January 2018 – September 2020 (n=392). Labels indicate the sample type, number of samples within each lipid category and percentage of the sample type compared to all submitted samples (%). CWG = choice white grease

Oxidative Stability Analysis

Samples were analyzed by Kemin CLS for their current oxidative status and stability by measuring: 1. active oxidation markers, including peroxides and secondary oxidative molecules (hexanal and 2,4-decadienal), and 2. resistance to future oxidation, as measured by the Oxidative Stability Index (OSI) at 100° C. The limit of quantification (LOQ) for secondary oxidatives and OSI were <5 ppm and 0.2 hours, respectively. Not all samples were tested for all parameters in the summary. Additionally, the presence of antioxidants was not tested for in all samples and is thus not reported.

Results

Current State of Oxidation

As oxidation takes place, peroxides are formed first and consumed, followed by secondary oxidatives which form as peroxides break down. The current state of oxidation of fat and oil samples based on peroxide value (PV) and total secondary oxidative levels are shown in Figure 2. As a general guideline, fats and oils should contain a PV less than 5 meq/kg and a total secondary oxidative value less than 50 ppm.[10] This is indicated in Figure 2 by the shaded box. Average PV and total secondary oxidatives for all samples were 3.4 meq/kg and 28 ppm, respectively. Peroxides ranged from 0 meq/kg to 47.8 meq/kg. Secondary oxidative levels varied from <LOQ (5 ppm) to 313 ppm. For samples that exceeded general guidelines, soybean oil and other animal fats tended to show elevated PV whereas CWG and other vegetable oils often showed elevation in both oxidative markers.

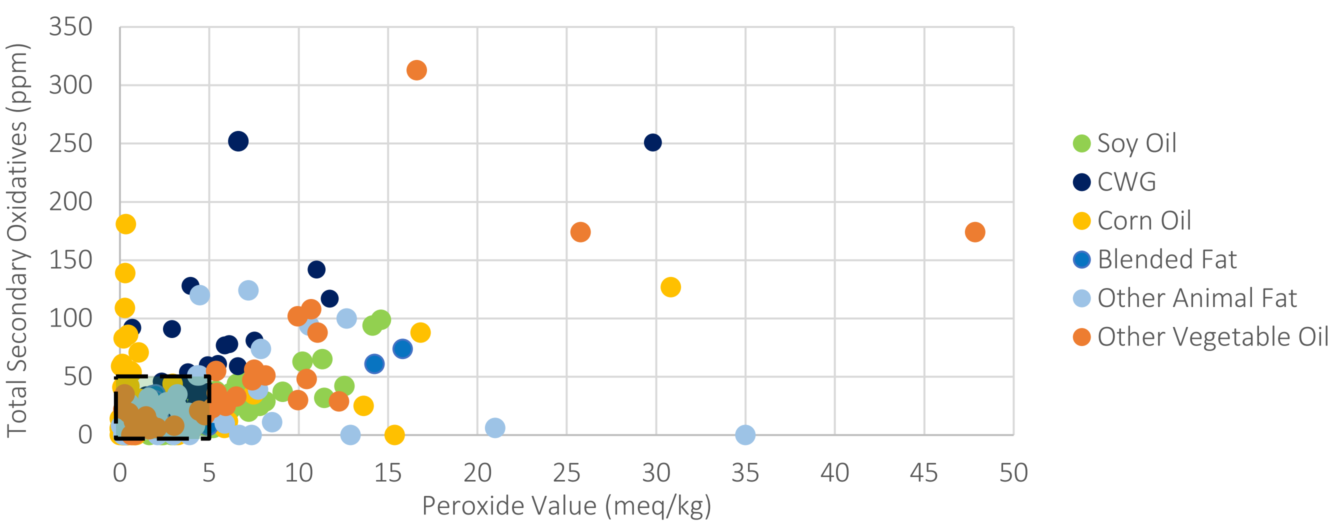

Figure 2. Peroxide value and total secondary oxidatives for fat and oil samples analyzed by Kemin CLS from January 2018 – September 2020 (n=392). The shaded box represents general guidelines for acceptable levels of active oxidation markers.

Based on PV and secondary oxidative levels (Figure 2), all analyzed samples were characterized into one of four oxidative status categories: no oxidation, early signs of oxidation, active oxidation or severe oxidation (Figure 3, Appendix 1). Overall, 39% of samples showed no signs of oxidation, 40% had early signs of oxidation, 16% were undergoing active oxidation and 5% were severely oxidized. Considering the sample counts (Figure 1), no oxidation was observed in the majority of corn oils (73%) and blended fats (70%). Early signs of oxidation were most frequently observed in CWG (67%) and other animal fats (46%). Soybean oil samples tended to show signs of early (48%) or active (41%) oxidation, while other vegetable oils most frequently showed active (34%) or severe (18%) signs of oxidation.

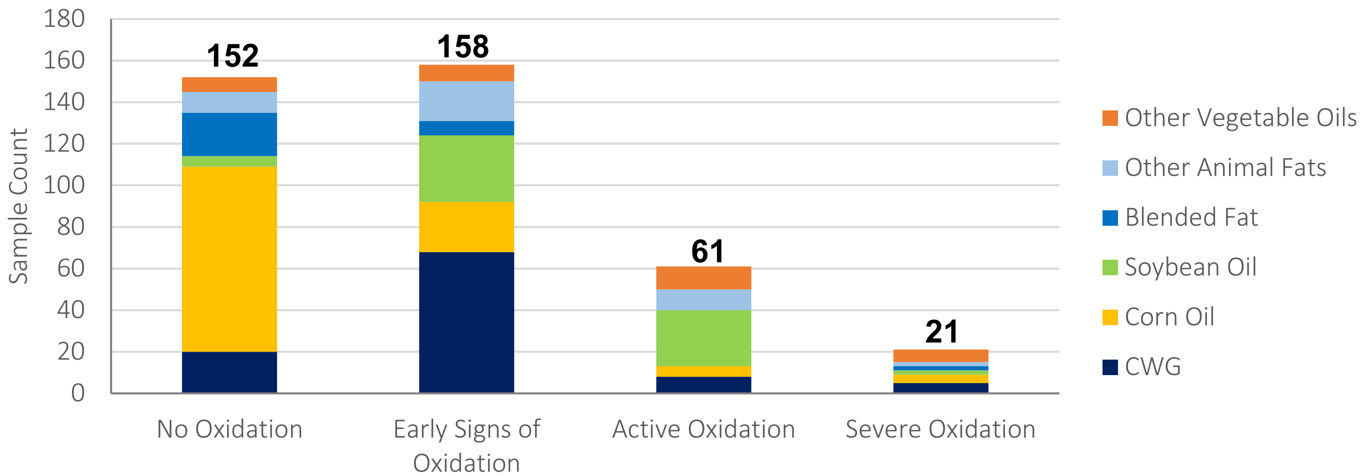

Figure 3. Oxidative status of fat and oil samples (n=392) analyzed by Kemin CLS from January 2018 – September 2020. The y-axis shows the number of samples from each sample type within the oxidation category shown on the x-axis. The number above each column represents the total number of samples within each oxidative status category.

Potential for Future Oxidation

The potential for oxidation of fat and oil samples was measured using OSI. A longer OSI time represents a delay in onset of oxidation and generally can be interpreted to represent a more stable product. The average OSI time for all samples was 17.4 hours, but OSI times varied significantly from 0.2 to 144 hours (Figure 4). For example, average OSI time for vegetable oils was 24.5 hours, whereas animal fats and blended fats average OSI times were 11.1 hours and 12.6 hours, respectively. This difference is likely due to the higher polyunsaturated fatty acid content of vegetable oils. Overall, 50% of samples had an OSI time less than 10 hours, and 46% of animal fats had OSI below 5 hours. Short OSI times can indicate enhanced susceptibility of lipids to future oxidation.

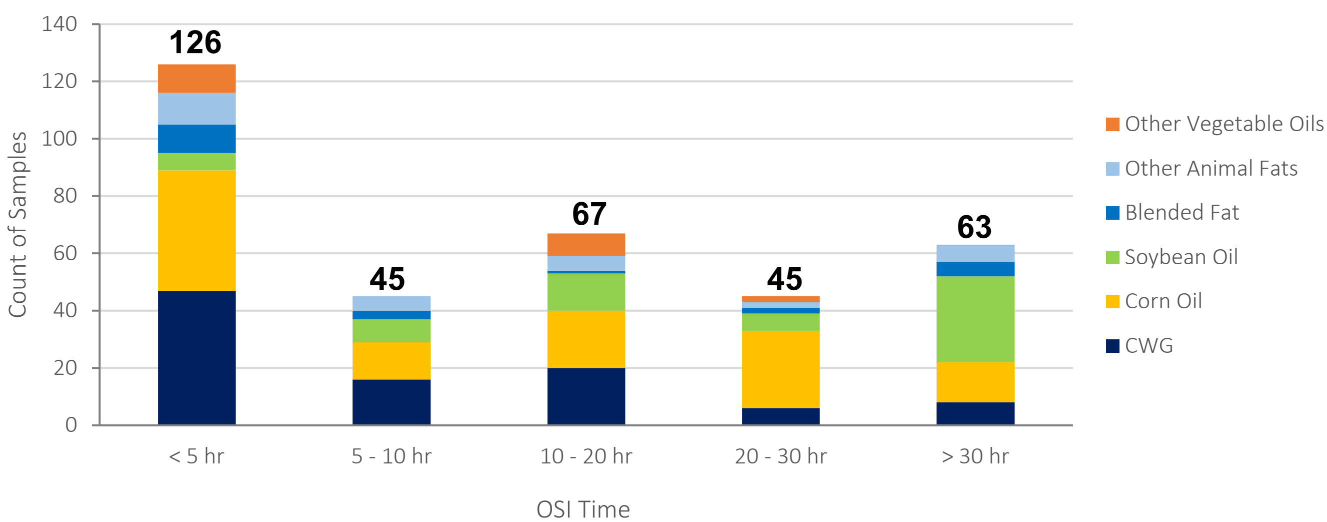

Figure 4. Oxidative stability index (OSI) of fat and oil samples (n=346) analyzed by Kemin CLS from January 2018 – September 2020. The y-axis shows the number of samples in each sample type with a given OSI time range on the x-axis. The number above each column represents the total number of samples within each OSI time range. A longer OSI time, generally, represents a delay in onset of oxidation.

Conclusion

The results of this study indicate that significant variability exists in both the current oxidative status and potential for future oxidation among supplemental fats and oils used in livestock and poultry diets. Based on analysis of current markers of oxidation (peroxides and secondary oxidatives), 61% of samples showed signs of early to severe oxidation. Additionally, 50% of samples were found to have short OSI times (< 10 hours), which suggests that these lipids are at elevated risk of future oxidation. Furthermore, variability in oxidative status was not limited to a specific lipid type, but rather was observed among animal fats, vegetable oils and blended fats alike.

Feeding oxidized lipids is known to have negative consequences to animal health and performance.[1-6] Therefore, managing lipid oxidation should be of high priority to nutritionists seeking to maximize the quality and nutritional value of livestock and poultry diets. One method to reduce variability in the oxidative status and improve the stability of fats and oils prone to oxidation is use of an antioxidant. Antioxidants work either by sacrificing themselves to quench free radicals or by acting as oxygen scavengers. Although antioxidants cannot reverse oxidation that has already occurred, limiting toxic oxidation molecules that can lead to oxidative stress or reduced feed palatability, may ultimately have a positive impact on livestock and poultry health and performance.

References

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Appendix

Appendix 1. Metrics used to categorize the oxidative status of fats and oils.

Stage	None	Early	Active	Severe
Peroxide Value (meq/kg)	< 1.5	1.5 to < 4	4 to <10	≥ 10
Total Secondaries (ppm)	< 25	25 to 49	≥ 50	≥ 50