Improving the Relationship between Petfood Stability, Nutrition, and Palatability

Presented at CBNA 2015
by
Kemin Industries, Inc.
The Relationship between Petfood Stability, Nutrition and Palatability

- Autoxidation Process
- Impact of Oxidized Diets on Animals
- Stabilization Programs for Petfood Diets
- Managing Palatability and Stability
Autoxidation Process

**INITIAL PHASE**

- T (°C)
- Cu ++, Fe ++, light

**PROPAGATION PHASE**

- Fat / Oil
- Free radicals

**TERMINATION PHASE**

- Protein
- Colour
- Nutritional Value
- Texture

**Irreversible**

**Self Propagating**

**Chemical interaction with molecular oxygen**

Krabbe, E. “Quality of raw materials” AMVEA Peru, 2013
Autoxidation Degrades Lipid Quality

Rancidity; Decreased Nutritional Value, Undesirable Aesthetic Changes

Krabbe, E. “Quality of raw materials” AMVEA Peru, 2013
Secondary Oxidation Products

• Breakdown products of fat oxidation
• Mostly short chain alcohols, ketones, aldehydes, epoxides
• According to Frankel (1987; Chem Phys Lipids 44:73)
  epoxy-hydroperoxides, oxo-hydroperoxide, hydorperoxy epidioxides, dihydroperioxides, hydroperoxy bis-epidioxides, and hydroperoxy bicycloendoperoxides.
The Relationship between Petfood Stability, Nutrition and Palatability

- Autoxidation Process
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Important Effects of Oxidized Diets on Animals
(list is not comprehensive)

- **Reduced nutrient value** (Turek et al., 2003 J Nutr Biochem 14:24-31)

- **Accumulation of harmful oxidation compounds** (Addis, 1986; Food Chem Toxicol 24:1021)


(Select examples follow)
Impact of Oxidized Fat Consumption on Puppy Vitamin E Status

Vitamin E Serum (PPM)

8 weeks  8 weeks  8 weeks  16 weeks  16 weeks  16 weeks

Low-Ox  Medium-Ox  High-Ox

Turek et al., 2003; J Nutr Bioch 14:24
## Impact of Oxidized Fat Consumption on Puppy Tissue Fatty Acid Levels

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>18:2n-6, mol/100mol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet</td>
<td>19.34(^a)</td>
<td>17.81(^b)</td>
<td>15.21(^c)</td>
</tr>
<tr>
<td>Plasma</td>
<td>24.00(^a)</td>
<td>23.44(^a)</td>
<td>21.92(^b)</td>
</tr>
<tr>
<td>Bone</td>
<td>13.71(^a)</td>
<td>11.46(^b)</td>
<td>9.29(^c)</td>
</tr>
</tbody>
</table>

Different superscript letters within a row are statistically different
# Impact of Oxidized Fat Consumption on Puppy Tissue Fatty Acid Levels

<table>
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<tr>
<th>Variable</th>
<th>Control</th>
<th>Medium</th>
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<tbody>
<tr>
<td>18:3n-3, mol/100mol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diet</strong></td>
<td>1.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Plasma</strong></td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td><strong>Bone</strong></td>
<td>0.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.38&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>22:6n-3, mol/100mol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diet</strong></td>
<td>0.496&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.556&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.67&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Plasma</strong></td>
<td>2.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.28&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.98&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Bone</strong></td>
<td>0.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.42&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

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Oxidized Dietary Lipids Depress Puppy Growth and Development

Turek et al., 2003; J Nutr Bioch 14:24
Impact of Oxidized Fat Consumption on Metabolism

• Dietary oxidized lipids make a major contribution to the level of oxidized lipids in circulating lipoproteins in rats (Staprāns et al., 1996. J Lipid Res 37:420-430)

• Feeding oxidation products of Linoleic Acid reduced fatty acid synthesis, and actetyl-CoA carboxylase (Minamoto et al., 1988; Biochim Biophys Acta 958:199)

• Oxidized Linoleic Acid:
  o incorporated into hepatic mitochondrial and microsomal lipids,
  o metabolized to neutral lipids and phospholipids,
  o lipid peroxides were injurious to rat liver (Kanazawa et al., 1986 Biochim Biophys Acta 879:36)
Consumption of Oxidized Fats has Negative Physiological Effects in Animals

• **Suppresses growth and development** (Lin et al., 1989 Br Poult Sci 30:855-864; Calabotta and Shermer, 1985; Eder et al., 2002; J Nutr 132:1275; DeRouchey et al., 2004; J Anim Sci 82:2937; Turek et al., 2003; J Nutr Bioch 14:24)


• **Affects immune response and inflammatory mediators** (Turek et al., 2003; J Nutr Bioch 14:24)

• **May lead to life-threatening diseases in extreme cases** (Bhat et al., 1995; Clin Toxicol 33:219; Kanazawa et al., 1988; J Nutr Sci Vitaminol 34:363; Alexander et al., 1987; J Toxicol Env Health 21:295; Budowski et al., 1979; Yang et al., 1998; Nutrition & Cancer 30:69)
Relationship between Stability and Palatability

Oxidation, indicated by Peroxide Value, reduced Dog Palatability

<table>
<thead>
<tr>
<th>Storage Conditions</th>
<th>Peroxide Value (meq / kg fat)</th>
<th>Consumption Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 weeks at 48.8°C</td>
<td>9</td>
<td>2.7</td>
</tr>
<tr>
<td>16 weeks at 48.8°C</td>
<td>28</td>
<td>1.0</td>
</tr>
</tbody>
</table>

An increase in oxidation, indicated by Peroxide Value, reduced Cat Palatability over time

### Effect of BHA + BHT Treatment of Meat Meals on Palatability of Chicken / Tallow Cat Diets Containing the Meals

<table>
<thead>
<tr>
<th>Time</th>
<th>Meal Treatment</th>
<th>Peroxide Value (meq / kg fat)</th>
<th>Consumption Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>BHA + BHT</td>
<td>4.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Initial</td>
<td>Untreated</td>
<td>7.3</td>
<td>1.0</td>
</tr>
<tr>
<td>3 months at 35°C</td>
<td>BHA + BHT</td>
<td>7.7</td>
<td>3.6</td>
</tr>
<tr>
<td>3 months at 35°C</td>
<td>Untreated</td>
<td>19.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Relationship between Stability and Palatability

- Chicken By-Product Meal Treatment
  - 1200 ppm Naturox® TX applied after the fat press (Control)
  - Untreated

- Cat Diet Palatability
  - Control Intake Ratio = 0.61 (p = 0.001)

- Stability of Cat Diets made with the meals
  - No difference in Peroxide Values (oxidative stability)
  - Minimal differences in Protein Oxidation By-Products
  - Cats very sensitive to stability, perhaps more so than analytical parameters
The Relationship between Petfood Stability, Nutrition and Palatability

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Role of Antioxidants

Antioxidants arrest rancidity by sacrificing themselves rather than allowing the oxidation of the fat or food nutrients.
Role of Antioxidants

- Protect fat and fat containing ingredients from autoxidation
- Reduce formation of “off” odors
- Reduce formation of toxic compounds
- Maintain energy value
- Protect nutrient stability, including vitamins and proteins
Role of Antioxidants

Delay rancidity by being preferentially oxidized (sacrificed) rather than allowing oxidation of the food nutrients.

Controlling the Autoxidation Process

• Antioxidants can control oxidation as long as active, residual levels are present (antioxidants cannot reverse oxidation)

• The higher the Initial Peroxide Value (IPV) the greater the chemical demand on the antioxidant

• Consumption of the antioxidant by a pro-oxidant effect leaves the material susceptible to oxidation
Stability Evaluation in Petfood Diets

• Ideal evaluation of pet food shelf life stability is real time stability, 12 – 24 months.

• Accelerated storage at an elevated storage temperature provides an estimate
  ○ 1 week at 37°C ≈ 3 – 4 weeks ambient
Shelf Life Case Study

- Challenging diet
  - High marine content
- Evaluation of raw materials
  - Meals were in good condition, oil was under treated
- Oil stability study
  - OSI with treatment options
- Kibble study with oil treatments
  - PV, oxidatives, antioxidant loss
Shelf Life Case Study

Step 1. OSI in oil, Antioxidant treatment comparison

- Naturox® Premium 2000 ppm
- Verdilox™ GT 8000 ppm
- Paramega™ XP 4000 ppm
Shelf Life Case Study

Step 2. Peroxide Value comparison for diet at two storage temperatures

**37°C**

- **Control**
- **8000 Verilox™ GT Liquid**
- **4000 Paramega™ XP Liquid**

**Ambient**

- **Control**
- **8000 Verilox™ GT Liquid**
- **4000 Paramega™ XP Liquid**
Shelf Life Case Study

Step 3. Antioxidant loss (Tocopherol) over time

- Control
- 8000 Verdilox™ GT Liquid
- 4000 Paramega™ XP Liquid
The Program Approach to Controlling Autoxidation

• Pet food diets are a complex matrix of fat, starch, and protein contributed by many ingredients

• Antioxidant treatment is needed at multiple points
  o All susceptible ingredients
  o At susceptible points in the process
  o Sufficient dosage required to protect the diet throughout the full shelf life

• Antioxidants may need to include:
  o Water and oil soluble components
  o Chelators to chelate pro-oxidant metals
  o Components that withstand and function at hot and cold temperatures
  o Dry and Liquid forms for optimum application
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Palatability is a Bellwether Parameter

The status of a pet food such as raw materials or texture….will be reflected in overall palatability.

….or changes in factors such as stability….will be reflected in overall palatability.
Managing Palatability and Stability

- PALFRESH™ technology provides another Stabilization Tool
  - Improving stability improves palatability
- This technology leverages the interaction between stability and palatability which *protects palatability*
Managing Palatability and Stability

• Hard to Stabilize Diets
  - Challenging or Pro-Oxidant ingredients and formulations
  - Low Fat diets that are subject to under-dosing and uneven coating
    ➢ Increased levels of antioxidants may not result in incremental increase in shelf life

• Palatability Decline
  - Although initial stability may obtained with a standard antioxidant program, palatability may decrease within the first three months of shelf life
    ➢ Antioxidant systems need to be optimized to preserve the palatant profile both pre- and post-coating
Managing Palatability and Stability

- Pro-oxidant palatants sacrifice antioxidant needed for long term shelf life of the diet
Managing Palatability and Stability with PALFRESH™ Palatants

✓ PALFRESH™ palatants are formulated to not have a pro-oxidant effect
Managing Palatability and Stability:
PALFRESH™ 4300 for Dogs

Standard Natural Control  Palfresh 4300

200 ppm Initial Minimum

Total Antioxidant (ppm)

0 Mo. - Ambient  3 Mo. - Ambient  6 Mo. - Ambient  2 Mo. - 37°C  4 Mo. - 37°C  6 Mo. - 37°C
Managing Palatability and Stability with PALFRESH™ Palatants

✓ PALFRESH™ palatants are formulated to not have a pro-oxidant effect

✓ PALFRESH palatants deliver target antioxidant effect to the diet at a uniform 3% application rate
Managing Palatability and Stability: Palfresh™ 4300 for Dogs

![Graph showing the intake ratio parity over time for canine diets with and without Palfresh 4300.](image)

- **Initial**: 0.57
- **3 months**: 0.65*
- **6 months**: 0.79**

*Average Intake Ratio Parity = 0.5, * denotes p<0.05, ** denotes p<0.001*
Managing Palatability and Stability with PALFRESH™ Palatants

✓ PALFRESH palatants are formulated to not have a pro-oxidant effect

✓ PALFRESH palatants deliver target antioxidant effect to the diet at a uniform 3% application rate

✓ PALFRESH palatants retain preferred pet acceptance through coated diet shelf life
Managing Palatability and Stability

- Polar botanical antioxidant systems are compatible and efficacious in aqueous palatants
- These unique liquid palatants contribute antioxidants to the finished diet
- Patent pending technology that reinforces the relationship between stability and palatability

PALFRESH™ Technology that protects palatability
THANK YOU