

# TIME IS MONEY OXIDATION AND THE BOTTOM LINE

*In Fresh Sausages and Ground Meats*



## CONSUMERS AND MEAT SELECTION

**Visual appearance is extremely important to consumers making buying decisions, particularly about the food they eat.** A pleasing appearance is tied to expected quality and is one of the most important factors in consumers' intention to purchase food.<sup>1</sup> When it comes to meat purchases, appearance is a visual cue that infers "expected meat quality attributes at the point of sale. These cues can be grouped into intrinsic (color, fat content, marbling) and extrinsic (price, origin, quality labels)."<sup>2</sup>

**"HUMANS ARE VISUALLY ORIENTED. WHAT WE SEE DIRECTLY IMPACTS OUR EXPECTATIONS ABOUT THE TASTE OF THAT PRODUCT"**

Herbert Stone, spokesperson and past-president, Institute of Food Technologists (IFT) and authority on sensory science, in "Adding Natural Red Color to Meat and Poultry"<sup>3</sup>

So, consumers 'eat with their eyes'—and they rely on an appealing appearance to ensure that their choices are fresh and flavorful. Product appearance and quality change during shelf life, impacting purchasing decisions; therefore, time is money when it comes to bottom line profitability.



## CONSUMERS AND MEAT SELECTION

### Color Makes the FIRST Impression

If consumers eat with their eyes, it follows that color is “one of the most important fresh meat characteristics at the point of purchase”<sup>4</sup>, with consumers using “inadequate color as an indicator of spoilage and wholesomeness.”<sup>5</sup> **Color is the visual cue that promises freshness, quality and deliciousness.**<sup>6</sup>

Simply put, consumers want to see:

Bright red fresh meat

Light pink cured meat

Light or dark pink ground poultry

Therefore, the color changes caused by oxidation impact consumer acceptability and influence initial purchasing decisions.

### Taste Leaves a LASTING Impact

What could be worse than creating a poor first impression? Following it up with a worse one. Color changes affect consumers’ initial impression and purchase decisions, but **flavor changes can negatively influence repeat purchasing decisions.**

Lipid oxidation is a primary reason for quality loss in meat and poultry products. During lipid oxidation, by-products degrade and compound into secondary oxidative by-products like aldehydes, which are primarily responsible for warmed-over flavor (WOF), described as cardboard-like, painty or rancid.

*Flavor changes caused by lipid oxidation are responsible for deterioration in quality and a negative taste experience, including off-flavors and off-odors that influence repeat purchase decisions.*

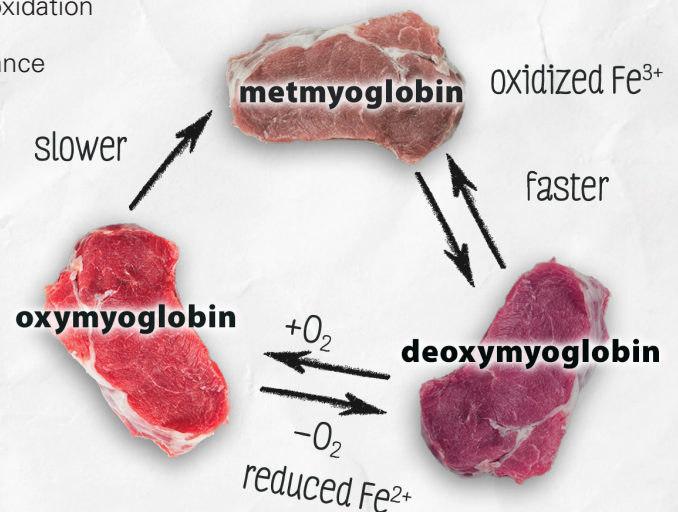
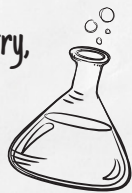


# THE SCIENCE BEHIND MEAT COLOR

## Oxidation At-A-Glance

- ▶ Color changes due to oxygen presence/absence and oxidation
- ▶ Microbial growth also impacts meat color and appearance

When it comes to meat and poultry,  
color has a certain chemistry.



## The most important protein for color in meat is myoglobin.

- ▶ The color of meat is determined by the ratios of the three forms of myoglobin which can be present.
- ▶ Stable oxymyoglobin imparts the bright red color that is considered a mark of freshness, and is formed and maintained in an oxygen-rich environment.
- ▶ Over time, the continuous oxidation transforms the myoglobin into metmyoglobin, imparting a brown color, a cue to consumers that the meat is no longer fresh.

## When Oxidation Starts

Beyond the science of oxidation lies the outcome—**oxidation impacts meat quality and consumer acceptability.**

Oxidation starts as soon as meat products leave the processing facility. And, this oxidation is affected by a variety of post mortem factors, including cold chain management and packaging. (Mancini, 2009).<sup>1</sup>

# TIME IS MONEY OXIDATION AND THE BOTTOM LINE IN FRESH SAUSAGES AND GROUND MEATS

## THE SCIENCE BEHIND MEAT COLOR

### Oxidation in Ground and Meat Fresh Sausage

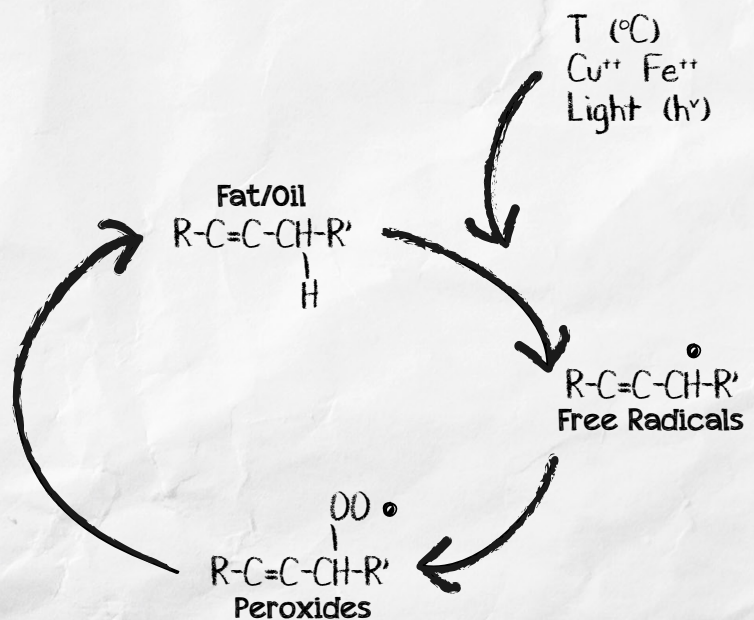
The popularity of ground meats and fresh sausage is undeniable. Ground beef remains the most popular type of beef among Americans, comprising 57% of the total beef consumed in this country.<sup>8</sup> From 2011 to 2016, sausage consumption in America has steadily risen from 231.88 million consumers to 246.81 million<sup>9</sup>, with the number of sausage consumers projected to hit 260.49 million by the year 2020.<sup>10</sup>

Fighting oxidation in ground meat and fresh sausage products can offer additional challenges. Since oxidation is affected by processing, packaging, and storing methods as well as product ingredients, processed ground meats and fresh sausages pose more complex issues. Oxidation occurs faster in meat products with a higher fat content, such as ground meats and sausages, leading to rancidity and a shorter shelf life. These products are more susceptible to oxidative degradation than meats with a lower fat content, since lipid oxidation and color oxidation fuel the same oxidation cycle. In addition, the chlorophyll in herbs and spices commonly added to processed meats absorbs light and accelerates the rate of photooxidation, which is exacerbated by the use of clear packaging and the display of products in lighted retail cases.

### Oxidation Is the Enemy: A Time Robber Out to Steal Your Profits

#### LIPID OXIDATION

Responsible for the deterioration in quality, including off-flavors and off-odors



Not only is oxidation the enemy, it is part of a vicious cycle, with lipid oxidation by-products exacerbating myoglobin (Mb) oxidation, which in turn further accelerates lipid oxidation.



## THE SCIENCE BEHIND MEAT COLOR

### Chemistry of Meat COLOR (as it relates to myoglobin oxidation)<sup>11</sup>

**Myoglobin (Mb) is the protein (globin) attached to a porphyrin ring containing a heme iron.**


Meat color depends on the iron (Fe) oxidation state and the type of ligand bound to the heme

Color loss is due to:

- oxidation of oxymyoglobin to metmyoglobin (brown)
- microbial load

Key measurables of meat color are:

- $a^*$  (redness)
- $L^*$  (lightness)



**Packaging** has an impact on the myoglobin oxidation process as well, with Hi-OX Modified Atmosphere Packaging (MAP) oxygenating myoglobin to oxymyoglobin (red/pink), while at the same time, lipid oxidation is encouraged due to high oxygen content.

### Chemistry of Meat FLAVOR (as it relates to lipid oxidation)<sup>12</sup>

Oxidation of unsaturated fatty acids develops in three phases:

#### INITIATION

- ▶ Hydrogen (H) atom is removed from a fatty acid by bonding with oxygen or other catalysts (heat, freezing, light, enzymes, metals, salt)
- ▶ Produces a free radical (R')

#### PROPAGATION

- ▶ Free radical reacts with oxygen, forming a peroxy radical
- ▶ Sets off a chain reaction

#### TERMINATION

- ▶ Final phase where oxidative by-products are formed, yielding off flavors and aromas
- ▶ Primary oxidative by-products: hydroperoxides
- ▶ Secondary oxidative by-products: alkenals, aldehydes, ketones, esters, hexanals, etc.
- ▶ Warmed-over flavor, rancid, cardboard-like flavors

## THE SCIENCE BEHIND MEAT COLOR

### Types of Oxidation, Auto- and Light-Induced



#### **AUTO OXIDATION**

Triplet oxygen oxidation – auto oxidation, happens regardless of light exposure



#### **LIGHT OXIDATION**

Singlet oxygen oxidation – mostly happens when singlet oxygen generated by photosensitizer under light exposure

**There are two types of lipid oxidation: auto- and light-induced.** Auto oxidation is triplet oxygen oxidation that happens regardless of light exposure, while light-induced or photooxidation is singlet oxygen oxidation that happens when singlet oxygen is generated by a photosensitizer under light exposure.

Meat products are especially susceptible to light-induced, or photo, oxidation, due to the photochemical reaction between light and fat lipids. Refrigerated lighted retail display cases are a primary cause, accelerating color loss in products including ground meats and fresh sausages. This color loss can be further affected by protein types, packaging methods, and light source, such as LED vs. fluorescent. The non-meat ingredients used in seasoned, packaged meats can also be to blame, with the chlorophyll in herbs and spices acting as a photosensitizer, and pyruvic acid and enzyme activity in onion, garlic, and chives also playing a role in the discoloration of meat products.

### Oxidation Prevention Methods

Oxidation can be prevented through a variety of techniques, including packaging methods, processing techniques, and the use of antioxidant ingredients. For instance, modified atmosphere packaging (MAP) utilizes an optimal blend of pure oxygen, carbon dioxide and nitrogen within a high barrier package. The various processing techniques used to enhance or alter the sensory or functional characteristics of meat products may include aging, cooking, mincing, comminution, or salting/curing<sup>13</sup>, and each of these techniques can affect the oxidation process.

**Antioxidant ingredients provide the most cost-effective prevention method** due to their level of effectiveness, their lack of negative impact on flavor, and their ability to provide targeted solutions. Since 65% of consumers sift through meat packages every time they shop<sup>14</sup>—and because product appearance and price are the top two factors of the consumer purchase decision—antioxidants offer a double benefit: that of protecting appearance and managing cost.



## ANTIOXIDANTS TO THE RESCUE



### What are Antioxidants?

In simplest terms, antioxidants are molecules that significantly delay or prevent lipid oxidation.

### ANTIOXIDANTS

- ▶ Significantly delay or prevent oxidation
- ▶ Help maintain fresh appearance and color
- ▶ Lengthen shelf life

### How do antioxidants work?

Antioxidants delay the onset of oxidation by donating hydrogen atoms to quench free radicals, forming a stable antioxidant radical that is unable to participate in propagation reactions, slowing down oxidation.





# TIME IS MONEY OXIDATION AND THE BOTTOM LINE IN FRESH SAUSAGES AND GROUND MEATS

## ANTIOXIDANTS TO THE RESCUE

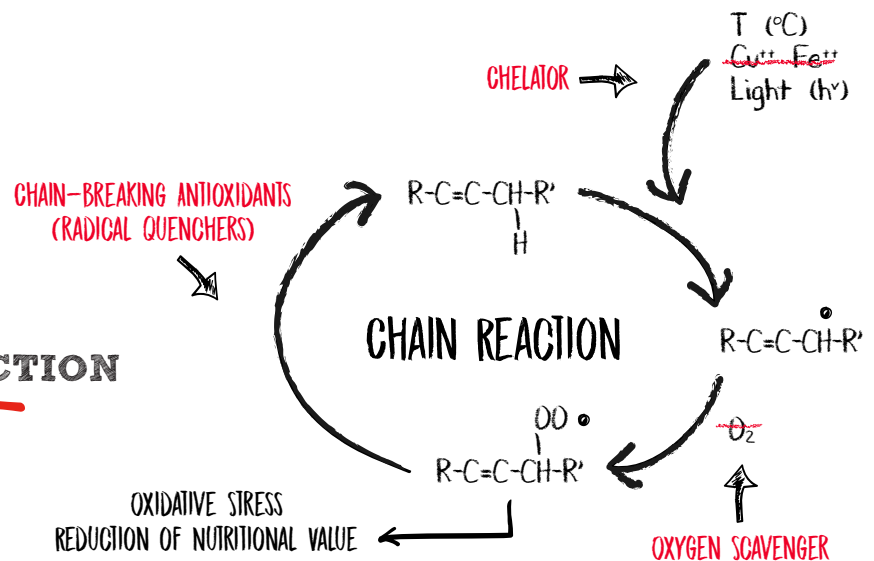
### Regarding Color Loss

**Antioxidants delay meat color loss**, as oxidation by-products interact with myoglobin and make heme iron susceptible to oxidation. Antioxidants delay myoglobin oxidation, maintaining consumer acceptance and therefore, lengthening shelf life.

### Regarding Flavor Degradation

**Antioxidants delay flavor degradation** by donating hydrogen atoms to quench free radicals caused by the onset of lipid oxidation. By delaying this onset and its negative effects, antioxidants help lengthen shelf life.

## ANTIOXIDANTS IN ACTION



# TIME IS MONEY OXIDATION AND THE BOTTOM LINE IN FRESH SAUSAGES AND GROUND MEATS

## ANTIOXIDANTS TO THE RESCUE

### Traditional and Clean-Label Options

Fortunately, there are also a wide variety of antioxidant options available, enabling meat and poultry manufacturers to meet any number of specific considerations and consumer demands.

**Traditional antioxidant options** include formulations made from synthetic ingredients that have been considered to be economical, easy-to-use, and time-tested:

Citric acid	Butylated hydroxyanisole (BHA)
Ascorbic acid	Butylated hydroxytoluene (BHT)
Sodium ascorbate	Tertiary-Butylhydroquinone (TBHQ)
Propyl gallate	

**Clean-label antioxidant options** offer an answer to consumer demands. Though different consumers may envision different definitions of clean, as a rule, these options are made with familiar ingredients with more natural, less processed components, including plant extracts with recognizable names such as rosemary and green tea.

"As consumer demand for clean, simple, natural ingredients continues to rise, meat and poultry processors are moving away from synthetic ingredients in favor of clean-label solutions. A number of plant extracts have been shown to ensure appealing color from processing plant to kitchen counter."<sup>15</sup> There has been a recent increase in the demand for domestically sourced, organic and non-GMO ingredients as well.

Today's consumers have never been savvier regarding their food choices,  
and they have never had more information at their fingertips.

While color remains a key factor, there is growing demand for products that are minimally processed and have consumer-friendly ingredient statements. Processors have a couple of options to achieve both. One that has been proven very effective in maintaining the bright red color in ground meats is the use of plant-derived extracts. These extracts can help preserve the appearance, taste and quality of meat products without negatively impacting flavor, color and odor profiles.



## SHELF-LIFE SOLUTIONS



### Acerola Cherry

Acerola cherry extract is a source of ascorbic acid, an oxygen reducer that functions as a reducing agent in fresh meats helping to maintain the heme iron in its reduced state, acts as a cure accelerator, and protects color. Acerola extract is also well known in the meat and poultry industry as a clean label source of nitrite.

**FORTIUM® A from Kemin** is a line of acerola extract-based curing accelerator or shelf-life solutions designed for maximum effectiveness against color degradation. Acerola cherry powder delays both lipid and myoglobin oxidation, thereby delaying the onset of color loss and maintaining the desirable color and quality of meat products.

*"Rosemary and green tea extracts are proven ingredients for their ability to positively impact the appearance, taste and quality of meat. Both contain phenolic compounds that function as antioxidants, preventing oxidative breakdown of meat pigments by being oxidized themselves."*<sup>16</sup>



### Rosemary

Rosemary extract contains numerous free radical scavengers, carnosic acid being one of the most well-recognized active components. Rosemary controls oxidation by delaying flavor and color loss in a variety of applications.

**FORTIUM® R from Kemin** is a complete line of rosemary extract-based antioxidants designed for maximum effectiveness against color and flavor degradation. It is also available in domestically grown organic varieties, providing a consumer-friendly alternative.



### Green Tea

Green tea extract contains active molecules, a subclass of flavonoids that donate their phenolic H to quench free radicals.

## SHELF-LIFE SOLUTIONS



### Blends

Using a blend of rosemary and green tea extracts offers enhanced protection, capitalizing upon the unique benefits of both extracts, in order to maximize flavor and color retention during long-term storage.

**FORTIUM® RGT from Kemin** is a versatile combination of rosemary and green tea extracts that extend shelf life. This blend provides superior antioxidant protection without negatively impacting flavor, color and odor profiles. When treated on an equal cost basis, a rosemary/green tea extract combination is a more effective consumer-friendly solution than rosemary or green tea extracts alone.<sup>17</sup>

**NaturFORT™ ARGT from Kemin** is a unique blend of acerola, rosemary and green tea extracts that provides optimal color and flavor shelf-life extension of meat and poultry products. Acerola cherry powder is an extract which is high in the natural form of ascorbic acid, which helps protect the color of a variety of food and beverage products.



### Traditional Synthetic

Traditionally used synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tertiary-butylhydroquinone (TBHQ) and propyl gallate offer cost-effective, reliable antioxidant solutions.

**EN-HANCE® synthetic antioxidants from Kemin** are synergistic blends formulated with time-tested active ingredients, including individual and ingredient blends of butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tertiary-butylhydroquinone (TBHQ), and propyl gallate. They protect food products from oxidation even when solubility, heat, and stability are an issue. EN-HANCE blends protect your products from oxidation, with low inclusion levels and no sensory impact.



## SHELF-LIFE SOLUTIONS

### Shelf-Life Extension Increases the Bottom Line

Increasing shelf life directly impacts the bottom line in the increasingly competitive meat and poultry market. A longer shelf life means a bigger profit margin. “Thus, it is very important to improve color stability because it will increase the shelf life of meat and meat products by increasing the time that meat will be visually accepted by consumers at the point of purchase.”<sup>18</sup>

Waste reduction is an important aspect that impacts the bottom line. It is estimated that 3.4 billion pounds of meat and poultry products were lost from the U.S. food supply at the retail and consumer level in 2010, comprising 24.5% of total food loss.<sup>19</sup> Shelf life can be increased by a variety of methods including: feeding antioxidants to livestock, using modified atmosphere packaging (MAP), or in sausages or ground meat, by adding antioxidants that minimize and delay the transformation of myoglobin into metmyoglobin, which is responsible for the brownish color.<sup>20</sup>

In addition to antioxidants, antimicrobials can be part of a complete shelf life package solution. There has been a shift to remove synthetic antimicrobials such as sodium lactate/diacetate from meat products, and buffered vinegar products have been shown to be effective in extending shelf life by controlling growth of food-borne pathogens, such as *Listeria monocytogenes*, in fresh and Ready-to-Eat (RTE) meat and poultry products, without negatively impacting the texture or flavor of the finished product.

### Extended Color Adds Value Per Day

In a recent study evaluating the efficacy of natural plant extracts on stabilizing the color and flavor of a frozen beef patty<sup>21</sup>, results showed antioxidant treatment yielded days of added color.

There was a significant ( $p < 0.05$ ) improvement in redness of the beef treated with a combination of acerola, rosemary and green tea extracts, versus the untreated control<sup>22</sup>.

#### Days of added color due to treatment:

Rosemary Extract = 1.5 days

Rosemary, Green Tea Extracts = 2.5 days

Acerola, Rosemary, Green Tea Extracts = 3.5 days



## SHELF-LIFE SOLUTIONS

### Customized Shelf-Life Solutions Give Manufacturers an Edge

Combinations of plant extracts are proven to be more effective than single ingredient solutions at protecting ground meat and fresh sausage products.<sup>23</sup> For instance, using a blend of rosemary and green tea extracts offers enhanced protection, as it capitalizes upon the unique benefits of both extracts, in order to maximize flavor and color retention during long-term storage.

A study conducted at the University of Nebraska–Lincoln meat lab<sup>24</sup> illustrates the superiority of acerola extract, rosemary extract, and green tea extract combination products over traditionally used rosemary in MAP ground beef stored under simulated retail display conditions.

The  $a^*$  (redness) values of the untreated control samples declined quickly when lighted storage began on day 5; however, the  $a^*$  values of **the samples treated with plant-derived extracts declined at a slower pace, because of the protective effects of the rosemary, green tea, and acerola extracts.**

Treatment effects became apparent on day 7, after two days of lighted storage, when ground beef treated with the acerola/rosemary/green tea extract combination generally had the highest  $a^*$  values, which corresponded to less discoloration and more intense red color during simulated retail display. The appearance of the untreated control was unacceptable on day 7, because it was brown, rather than the typical bright cherry red color of fresh beef. On days 8 and 9, the ground beef treated with the extract combination was noticeably more red and had numerically higher  $a^*$  values than the other treatments.

Shelf-life and antioxidant effectiveness varies based on type of product and processing method. Performance is maximized by adding shelf-life solutions as soon as possible in the manufacturing process and by utilizing the optimal solutions, either combined with seasoning ingredients in a dry or liquid state or added to brine as a water-soluble liquid or dry solution.

Flavor threshold is paramount in terms of consumer acceptability. And, perhaps most importantly, when it comes to consumers: “To enhance consumer perception (both expected and experienced) of meat and meat products, additional information provided at the point of purchase (Grunert et al., 2004) may play an important role in reducing uncertainty in the formation of quality expectations.”<sup>25</sup> This includes the informational cues available at the shopping place such as the product’s appearance and color, its label information, and its price—all factors that can be positively impacted by the proper antioxidant and antimicrobial ingredient solutions.



# ANTIOXIDANT EXPERTS AT KEMIN

When it comes to meat and poultry products, antioxidant solutions don't work in a vacuum, so an integrated approach is an important component of their successful implementation.

## Experienced Technical Team Understands Ingredient Synergies

It is important to work with a supplier with an experienced technical team who understands the synergies of meat and poultry ingredient behaviors, as well as the interaction with their packaging materials. Kemin offers manufacturers the technical expertise and protein knowledge to answer production challenges, while providing customized shelf-life solutions.

Kemin's highly experienced R & D team has the ability to understand proteins, as well as how different processing techniques, other ingredients used, and packaging options can impact consumer appeal and shelf life. The Kemin R & D team uses a model protein matrix to screen extracts and evaluates your finished product to determine dose response. They understand the synergies of ingredient behaviors, and know that ingredient adjustments, vs. processing or packaging changes, are the most cost-effective method to delay oxidation. The team uses formulation technology to determine the optimal and most cost-efficient inclusion rate in each meat matrix. In today's highly competitive marketplace, Kemin provides food processors, manufacturers and formulators the ability to reduce costs, control inventory and meet demand, all while providing the visual appeal and flavor protection consumers demand.

## Customer Lab Services (CLS) for added value

In addition, Kemin provides complimentary Customer Laboratory Services (CLS), with a team providing dedicated support throughout all phases of testing, using a combination of analytical techniques and accelerated oxidation tests to provide proof-of-principle for solutions. This free in-house service reduces testing time during formulation or reformulation of products, helping meat and poultry manufacturers meet their go-to-market goals.

For more information, visit [kemin.com/OXIDATIONCONTROL](https://www.kemin.com/OXIDATIONCONTROL) or 800.777.8307





## Sources

<sup>1,2</sup> Maria Font-i-Furnols, Luis Guerrero, "Consumer Preference, Behavior and Perception About Meat and Meat Products: An Overview," Meat Science, June 18, 2014, p. 364.

<sup>3</sup> Donna Berry, "Adding Natural Red Color to Meat and Poultry," MeatPoultry.com, May 30, 2017.

<sup>4,5</sup> Font-i-Furnols, Guerrero, p. 364.

<sup>6</sup> Donna Berry, "The Color of Meat," FoodBusinessNews.net, August 15, 2016.

<sup>7</sup> Mancini

<sup>8</sup> "GroundBeef Nation: The Effect of Changing Consumer Tastes and Preferences on the U.S. Cattle Industry," Rabobank AgFocus, January, 2014.

<sup>9,10</sup> "Sausage Stats," Meat+Poultry.com, February 16, 2017.

<sup>11</sup> Travis Krause, "Color & Lipid Oxidation in Meats," PowerPoint presentation, p. 4.

<sup>12</sup> Krause, p. 11.

<sup>13</sup> O.P. Soladoye, M.L. Juárez, J.L. Aalhus, P. Shand, M. Estévez, "Protein Oxidation in Processed Meat: Mechanisms and Potential Implications on Human Health," Comprehensive Reviews in Food Science and Food Safety, February 9, 2015, p. 109.

<sup>14,15,16</sup> Berry, "The Color of Meat"

<sup>17</sup> Michael Fielding, "Kemin Rosemary, Green Tea Extract Blend Outperforms Rosemary Extract Alone," <http://www.meatingplace.com/Industry/TechnicalArticles/Details/63855>, February 1, 2016.

<sup>18</sup> Maria Font-i-Furnols, Luis Guerrero, p. 365.

<sup>19</sup> Jean C. Buzby, Hodan F. Wells, and Jeffrey Hyman, "The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States," USDA Economic Information Bulletin, Number 121, February 2014, p. 12.

<sup>20</sup> Maria Font-i-Furnols, Luis Guerrero, p. 365.

<sup>21</sup> Travis Krause, "Color & Lipid Oxidation in Meats," PowerPoint presentation, p. 27.

<sup>22</sup> Krause, p. 29.

<sup>23</sup> Krause, p. 39.

<sup>24</sup> "Color Stability of Modified Atmosphere Packaged (MAP) Ground Beef Treated with Natural Plant Extracts," Kemin Food Technologies, Document INF-2015-00001.

<sup>25</sup> Font-i-Furnols, Guerrero, p. 364.