EASTMAN

Improving shelf-life characteristics of meat and poultry

with Eastman Tenox™ food-grade antioxidants

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Contents

Products from the meat-packing and poultry-processing industries constitute a significant portion of the world's diet. Some of these products are rendered fats used in processing or fabricating other food products such as sausages, dried meats, and raw meats.

Meat and poultry products are susceptible to oxidation, which produces rancid flavors and odors. Eastman Tenox™ food-grade antioxidants added to such products will help control oxidation and help ensure that the foods reach the consumer in the best possible condition. Tenox antioxidants are available as single-antioxidant products or as solutions with combinations of antioxidants.

This publication presents the properties and advantages of each Eastman Tenox™ antioxidant suitable for meat and poultry products so the optimum choice can be made for each application.

Controlling oxidative rancidity in meat and poultry products

Fats and oils in meat and poultry products react with oxygen to form peroxides that break down into short-chain compounds such as aldehydes, ketones, acids, and alcohols. Factors such as heat, light, and trace metals catalyze the chain reaction. The rancid fats resulting from oxidation develop undesirable odors and flavors and can lower the nutritive value of food. The result is an economic loss for food processors and marketers.

Antioxidants delay the development of oxidative rancidity[1,2] by absorbing the energy of the activated fat molecules, thereby increasing product shelf life.

Eastman offers several antioxidants useful in controlling rancidity in meat and poultry products.

Solid food-grade antioxidants

Eastman Tenox™ TBHQ (tertiary butylhydroquinone)
Eastman Tenox™ BHA (tertiary butylhydroxyanisole)
Eastman Tenox™ BHT (tertiary butylhydroxytoluene)

The product line of Eastman Tenox™ antioxidants includes solutions containing combinations of TBHQ, BHA, and BHT. Some of the solutions include citric acid as a chelating agent and synergist to overcome the pro-oxidant effects of trace metals or to enhance the activity of the antioxidant. These easy-to-handle solutions, prepared with edible solvents, provide maximum antioxidant effectiveness.

Each Eastman Tenox™ antioxidant (see Table 1) has specific characteristics[3] that make it potentially more useful or effective in certain applications. Producers of meat or poultry products obtain optimal results by choosing the appropriate Tenox antioxidant for a particular stabilization need. The proper choice will:

- Protect the quality of meat or poultry products.
- Expand the marketing area because of increased product shelf life, while maintaining freshness, flavor, and odor for a longer period of time.
- Minimize product loss.
- Increase consumer satisfaction.

Table 1 Eastman Tenox™ food-grade antioxidants for meat and poultry products[a]

	Characteristics		Composition, wt % active ingredients			
Product	Physical state	Typical color	BHA	BHT	TBHQ	Citric acid
Eastman Tenox™ BHA	Tablets or flakes	White to light tan	100	—	—	—
Eastman Tenox™ BHT	Granular crystals	White to light tan	—	100	—	—
Eastman Tenox™ TBHQ	Crystals	White to light tan	—	—	100	—
Eastman Tenox™ 4	Liquid	Light straw	20	20	—	—
Eastman Tenox™ 20	Liquid	Light amber to golden brown	—	—	20	10
Eastman Tenox™ 20A	Liquid	Golden brown	—	—	20	3
Eastman Tenox™ 25	Liquid	Golden brown	—	10	10	3
Eastman Tenox™ CA-50[b]	Liquid	Colorless to light straw	—	—	—	50

[a] *For complete listing and composition, see publication ZG-262.*

[b] *Solution contains 50% citric acid and 50% propylene glycol. It can be added during or after the refining process to help overcome the pro-oxidant effect of trace metals.*

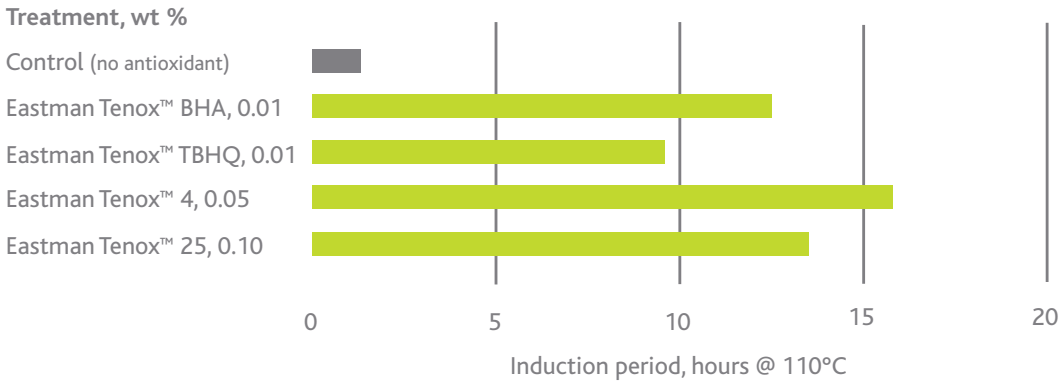
Eastman Tenox™ food-grade antioxidants in rendered animal and poultry fats

Rendered animal fats

Because rendered animal fats, such as lard, have virtually no natural antioxidant protection, they are especially susceptible to oxidative deterioration and rancidity. Eastman Tenox™ antioxidants can benefit these edible animal fats and the various foodstuffs produced from them by improving fat stability during shipping and storing and by providing "carry-through" protection for increased shelf life.[4]

Laboratory tests have shown the effectiveness of Tenox antioxidants in rendered animal fats (see Figure 1). For a description of the tests, see page 9.

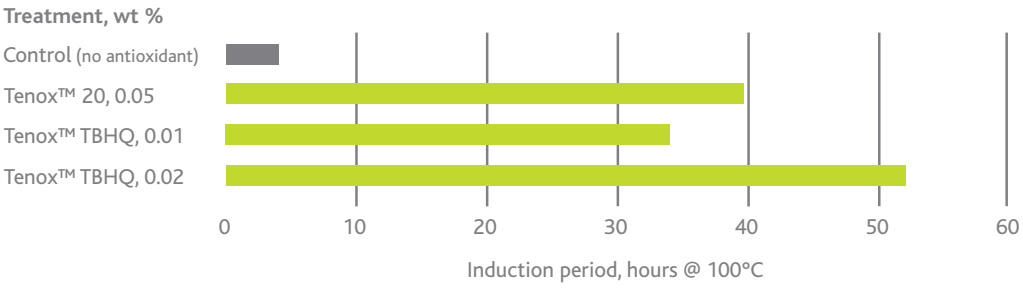
Figure 1 Oil stability index of lard



Rendered poultry fats

Fabricated poultry products such as soups, soup mixes, and creamed products contain rendered poultry fats, which are unsaturated and quickly turn rancid. Laboratory tests have shown that Eastman Tenox™ antioxidants improve the oxidative stability of rendered poultry fats (see Figure 2).

Figure 2 Oil stability index of poultry fats



Additional methods

Eastman Tenox™ antioxidants may be added to fats in numerous ways. For maximum effectiveness, the method chosen must completely dissolve or disperse the antioxidant. Producers of lard and other edible fats use two basic methods: the direct method and the proportionate method.

Direct method

Producers of lard and other edible fats use this procedure most often:

- Heat the fat to 70°C ± 10°C (158°F) and agitate until all fat is in melted (but not so vigorously that excessive air is entrapped).
- Add antioxidant at a rate of approximately 1 gallon every 5 to 10 minutes.
- Continue agitating 20 minutes after antioxidant is added to ensure complete, uniform distribution.

Proportionate method

- Proportion or meter the antioxidant solution or concentrated antioxidant into a pipeline through which the hot (60°C [140°F] minimum) fat is being circulated, using a stainless steel proportioning pump.

The success of this technique depends on the pipeline length and turbulence provided by the circulating pump. The pipeline should be at least 2 inches in diameter and approximately 100 feet long. Provide enough turbulence to thoroughly mix the antioxidant in the fat before the mixture reaches the final storage tank.

Eastman Tenox™ food-grade antioxidants in meat and poultry products

Beef products

Oxidation of the lipids (fats) in raw and cooked meats and meat products reduces their quality. Adding Eastman Tenox™ antioxidants helps protect meat products against oxidative deterioration.[5,6]

Consumers increasingly rely on precooked, prepackaged meat (particularly ground beef) products. Studies on antioxidants in cooked ground beef patties show that "TBHQ antioxidant retards flavor deterioration and oxidative rancidity in cooked ground beef patties."[7]

Poultry products

Oxidative rancidity develops more rapidly in certain types of poultry products, such as ground turkey, turkey patties, and fried chicken.[8,9] The rancidity becomes more prominent when the poultry has been cooked.[10] Studies show that using Eastman Tenox™ BHA antioxidant in poultry products significantly retards oxidation.[11]

Sausage products

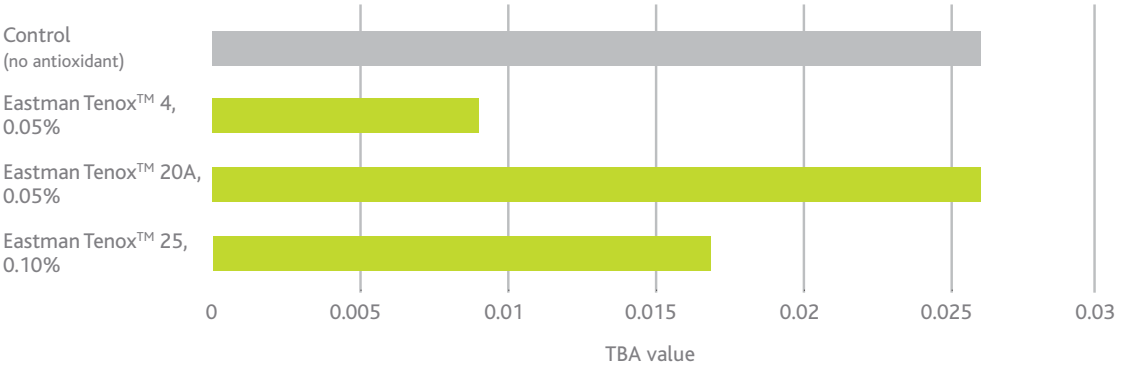
Sausage products easily oxidize, even in freezers where conditions inhibit oxidative rancidity in most products.[12] This tendency is due to several factors:

- Grinding meat increases surface area and exposure of lipids to oxygen.
- Heme pigments in meat are in contact with lipids and catalyze their oxidation.
- High levels of salt in sausage strongly catalyze oxidation, especially under freezer storage conditions.

The effectiveness of selected Eastman Tenox™ antioxidant solutions in fresh pork sausage has been determined by TBA (2-thiobarbituric acid) (see method, page 9). Fresh pork sausage was treated with Tenox antioxidant solutions based on the fat weight and stored at 0°–4°C (32°–40°F).

As Figure 3 shows, Tenox 4 antioxidant solution, containing BHA and BHT, was the most effective of those tested. TBA values for sausage treated with Tenox 25 antioxidant solutions were also significantly lower than the control.

Figure 3 **TBA values for sausage[a] Duncan's multiple range test**



[a]*Averages for 31 days*

For antioxidants to be effective in sausage products, they must be thoroughly distributed and in contact with fatty portions of the product. This can be accomplished by these methods:

- Spraying an antioxidant solution onto the meat trimmings as they are fed into a grinder
- Incorporating antioxidant in the seasoning mix
- Using antioxidant-treated salt (available from salt suppliers)

Freeze-dried meats

Lipid oxidation causes freeze-dried meats to deteriorate rapidly.[13] High levels of unsaturated lipids may oxidize rapidly, especially when meat pigments — strong oxidation catalysts — are present. Studies have shown the effectiveness of antioxidants in freeze-dried meats.[14]

Antioxidant solutions can be applied to freeze-dried meats by spraying onto the freshly-dried meat before packaging.

Stability tests for determining effectiveness of Eastman Tenox™ food-grade antioxidants in meat and poultry products

Oxidative stability of antioxidant-treated meat and poultry products can be determined by storing samples at normal use conditions and examining them periodically for odor or flavor changes or by testing them chemically for rancidity. These procedures generally take much time; accelerated tests are often used to compare untreated and antioxidant-treated products.[15] Accelerated tests are particularly useful for quality control and product development.

Active Oxygen Method

The Active Oxygen Method (AOM)[16] has been widely used for years on fats and oils that are liquid at the test temperature. It is not applicable to solid material. Air is bubbled through the heated test sample to speed oxidation and shorten testing time. Periodic analyses show when the peroxide content reaches the rancidity point. For animal and poultry fats, that point is 20 meq peroxide/kg of fat.

The AOM is labor-intensive and can take substantial time. Although some processors continue to use the method the American Oil Chemist's Society (AOCS) discontinued the AOM as an approved method in 1994.

Oil Stability Index

The Oil Stability Index[17] is an automated, accelerated method of measuring stability of fats and oils. Fat or oil samples held at a constant temperature between 110° and 130°C are exposed to a stream of purified air. Over time the oil or fat begins to oxidize, giving rise to volatile organic acids. The volatile decomposition products, trapped in a measuring vessel filled with distilled water, are continuously monitored with a conductivity cell. The "induction period" is the period at which the rapid acceleration of oxidation occurs and is recorded as number of hours.

TBA number

Although many methods have been used to measure lipid oxidation in meat products, the TBA[18] method is the most widely used. Secondary oxidation products react with 2-thiobarbituric acid (TBA), forming a colored complex. The complex is measured with a spectrophotometer at a wavelength of 530 nm. The TBA number is the mg malonaldehyde/kg of meat. It derives its name from the reddish complex that malonaldehyde forms with TBA.

Oven storage tests (Schaal Oven)

Oven storage tests are simply shelf storage tests conducted at high temperatures to speed oxidation. Periodic odor and flavor evaluations or chemical analyses, e.g., peroxide value,[19] are used to determine rancidity in the samples.

United States regulatory status and labeling requirements

In accordance with regulations administered by the Food Safety and Inspection Service (FSIS), United States Department of Agriculture (USDA), it is lawful to use BHA, BHT, or TBHQ in meat food products and poultry food products [9 CFR 424.21(b)(1)]. These antioxidants may be used singly or in combinations of two or more. Examples of maximum permitted levels of use include the following:

Meat and meat food products	Maximum permitted usage level
Rendered animal fat or a combination of such fat with vegetable fat	0.01% (100 ppm) singly, 0.02% (200 ppm) in combination, with no single antioxidant exceeding 0.01% (100 ppm)
Dry sausage	0.003% (30 ppm) singly, 0.006% (60 ppm) in combination, with no single antioxidant exceeding 0.003% (30 ppm) based on total weight of finished products
Fresh pork sausage, brown-and-serve sausage, Italian sausage products, pregrilled beef patties, and fresh sausage made from beef and pork	0.01% (100 ppm) singly, 0.02% (200 ppm) in combination, with no single antioxidant exceeding 0.01% (100 ppm) based on fat or oil content of finished product
Dried meats	0.01% (100 ppm) singly or in combination based on total weight of finished product

Poultry and poultry food products	Maximum permitted usage level
Various poultry products including rendered poultry fat or a combination of such fat with vegetable fat	0.01% (100 ppm) singly, 0.02% (200 ppm) in combination, with no single antioxidant exceeding 0.01% (100 ppm) based on fat content

Because of possible legal and regulation changes as well as possible changes in products, no guarantee is made that the USDA status of these products will remain unchanged.

The FDA regulates the labeling of ingredients in a food product including antioxidants. Customers must be guided by the advice of their own legal counsel for proper labeling.

For more information about Eastman Tenox™ food-grade antioxidants, call 423-229-2000 or visit www.eastman.com.

References

1. Sherwin, E. R., 1978, "Oxidation and Antioxidants in Fat and Oil Processing," *J. Am. Oil Chem. Soc.* 55(11): 809–814.
2. Lundberg, W. O., 1962, "Oxidative Rancidity in Food Fats and Its Prevention," Ch. 11, *Autoxidation and Antioxidants*. Interscience Publishers, Inc., New York.
3. Furia, T. F., 1968, "Antioxidants as Food Stabilizers," Ch. 4, *Handbook of Food Additives,* 185–223, The Chemical Rubber Co., Cleveland, Ohio.
4. Dugan, L. R., Jr., 1960, "Antioxidants That Protect Your Fats and Foods Made With Them," December 1960, Circular No. 63, American Meat Institute Foundation.
5. Love, J. D. and Pearson, A. M., 1971, "Lipid Oxidation in Meat and Meat Products—A Review," *J. Am. Oil Chem. Soc.* 48: 547–549.
6. Keller, J. D. and Kinsella, J. T., 1973, "Phospholipid Changes and Lipid Oxidation During Cooking and Frozen Storage of Raw Ground Beef," *J. Food Sci.* 38: 1200–1204.
7. Van de Reit, S. J. and Hord, M. M., 1979, "Flavor Quality of Antioxidant-Treated, Cooked Ground Beef Patties," *J. Am. Diet. Assoc.* 11.
8. Olson, V. M. and Stadelman, W. J., 1980, "Antioxidant Control of Rancidity Development in Ground Turkey Meat," *Poultry Sci.* 59(12): 2733–2737.
9. Nonaka, N. and Pippen, E. L., 1966, "Volatiles and Oxidative Flavor Deterioration in Fried Chicken," J. Agric. Food Chem. 14(1): 2–4.
10. Jacobson, J. N. and Koehler, H. H., 1970, "Development of Rancidity During Short-Time Storage of Cooked Poultry Meat," *J. Agric. Food Chem.* 18(6): 1069–1072.
11. Dawson, L. E., Stevenson, K. E. and Gertonson, E., 1975, "Flavor, Bacterial, and TBA Changes in Ground Turkey Patties Treated With Antioxidants," *Poultry Sci.* 54: 1134–1139.
12. Paul, D. L., Griesbach, R. H. and Jaeger, J. F., 1968, "Method of Preserving Fresh Frozen Pork Sausage," U.S. Patent 3,366,495, January 30.
13. Chipault, J. R. and Hawkins, J. M., 1971, "Lipid Oxidation in Freeze-Dried Meats," *J. Agric. Food Chem.* 19(3): 495–499.
14. Pintauro, N. D., 1974, "Food Additives to Extend Shelf Life, Antioxidant for Freeze-Dried Meat," *Food Technology Review,* 89, Noyes Data Corp., Park Ridge, New Jersey.
15. Wan, P. J., 1995, "Accelerated Stability Methods," *Methods To Assess Quality and Stability of Oils and Fat-Containing Foods,* Warner, K. and Eskin, N. A. M. (eds.), 179–189. AOCS Press, Champaign, Illinois.
16. AOCS, 1993, *Official and Tentative Methods,* 4th ed. Method Cd 12-57, American Oil Chemist's Society, Chicago.
17. AOCS, 1993, *Official and Tentative Methods,* 4th ed. Method Cd 12b-92, American Oil Chemist's Society, Chicago.
18. AOCS, 1993, *Official and Tentative Methods,* 4th ed. Method Cd 19-90, American Oil Chemist's Society, Chicago.
19. AOCS, 1993, *Official and Tentative Methods,* 4th ed. Method Cd 8-53, American Oil Chemist's Society, Chicago.

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