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K·STATE
Kansas State University
Animal Sciences and Industry
K-State Research and Extension
232 Weber Hall
Manhattan, KS 66506-0201
785-532-6533
Fax: 785-532-7059

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Laura M. Tarantino, Ph.D.
Director, Office of Food Additive Safety
Center for Food Safety and Applied Nutrition
Food and Drug Administration
5100 Paint Branch Parkway
College Park, MD 20740

Re: Use of Carbon Monoxide in Fresh Meat Packaging; Docket No. 2005P-0459

Dear Dr. Tarantino:

I offer these comments to address three issues related to the use of carbon monoxide (CO) in the modified gas atmospheres of packaged fresh meat: the GRAS status of CO; the relationship between CO and meat color; and the role of meat color in consumer selection and acceptance.

I am a professor of meat and food science at Kansas State University. During most of my professional career I have specialized in studying meat color and muscle pigment chemistry, including color stability research of meat in various packaging formats. I have first-hand experience with several studies where CO has been part of package atmospheres. These comments are mine only and offered as a scientist interested in meat packaging technology.

CO as GRAS:
Having served as a member of the GRAS panel for one of the CO applications reviewed by FDA (GRAS Notice No. 83), I am familiar with the FDA GRAS notification process and its requirements. I also have closely followed the review process of several petitions for use of CO in fresh meat packaging, including those addressing use of CO in retail packages. From a meat quality, product safety, and meat pigment chemistry viewpoint, the current GRAS status for CO is consistent with many years of decision making.

From a safety perspective, even those objecting to CO do not seem to question its toxicity with respect to the intended use. The primary objection appears to be that CO affects the color of meat in a way that impacts safety, by allowing color to remain stable even if the cold chain is not maintained properly. The relationship between meat color and safety is tenuous at best, as much of the meat marketed in this country spends a substantial portion of its shelf life in packaging systems where color gives few clues for spoilage.

For example (and there are others) nearly all bulk meat intended for traditional retail-store processing and packaging is transported to retailers in a vacuum, low-oxygen environment that maintains color in a purple-red pigment known as deoxymyoglobin. This system has been the normal process in the US for well over 40 years. Though I believe modern cold chain management to be excellent, in the unlikely event that these bulk products are mishandled in a way that would allow spoilage or pathogen growth, the meat would still bloom and exhibit the bright-red color of oxymyoglobin when exposed to air. Odor and other signs of spoilage would need to be relied upon to evaluate the condition of these products. I know of no reason why low-oxygen systems with CO should be viewed any differently from a safety or spoilage perspective than other low-oxygen systems widely in use, and I am aware of no credible controversy in the scientific community on this point. GRAS is where low-oxygen CO packaging should stay.

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CO and Meat Color:
Under ultra-low oxygen concentrations, CO can form a bond with myoglobin, creating a bright-red color called carboxymyoglobin (COMb). Oxygen will form a similar, bright-red pigment called oxymyoglobin (OMb). These two redox forms of myoglobin are extremely hard to differentiate, and if a consumer did so correctly, it would be the pure luck of chance. Visually they are identical in appearance. If there are slight differences in meat appearance it is likely due to the inherent properties of the muscle that modify appearance, the native myoglobin pigment concentration in the muscle, or very likely the partial pressure of the gases contacting the meat. In this regard, the effects of CO and oxygen would be essentially the same.

As FDA scientists are well aware, molecules can often be identified and characterized by determining their absorbance spectra. The absorbance maxima for myoglobin and hemoglobin have been known for years. Absorbance of COMb and OMb are extremely similar, usually no greater than 1 to 4 nm at their major absorbance wavelengths [E. Antonini and M. Brunori. 1971. *Hemoglobin and Myoglobin in their Reactions with Ligands,* in Frontiers in Biology, V21:13, Eds: A. Neuberger and E.L. Tatum, North-Holland, Amsterdam]. These differences are too close to reliably differentiate the two pigment forms. The practical application of these facts is that it takes extremely accurate analytical chemistry to be able to detect which pigment form is which. One could argue that the colors are not "exactly" the same as a matter of chemistry, but for the practical marketing of meat, where the issue is consumer perception of appearance, they are identical. If one uses reflectance spectrophotometry, as is commonly done by the food and paint industries for quality control, these instruments would not be able to differentiate these two pigments.

The high-oxygen MAP format that is being touted as being safer and more consumer friendly than the CO format, gets its enhanced color stability by exposing the meat to four times the amount of oxygen in air. Product in 80% oxygen is brighter red due to a deeper layer of oxymyoglobin than product packaged in 0.4% CO, but its flavor stability is greatly reduced [John et. al. 2005. Color and thiobarbituric acid values of cooked top sirloin steaks in modified atmospheres of 80% oxygen, or 0.4% carbon monoxide, or vacuum. Meat Sci. 69:441-449]. All this begs the question as to which package has a "new" color. The science behind the color would say neither has a "new" color. Thus, consumers are not being exposed to a "new" color that is misleading consumer perception; rather they have been viewing this red hue in meat retail packages for years.

Little has been mentioned of the fact that essentially 100% of the product packaged in the 80% oxygen system will "prematurely brown" when cooked by consumers [Seyfert et. al. 2004. Internal premature browning in cooked steaks from enhanced beef round muscles packaged in high-oxygen and ultra-low oxygen modified atmospheres. J. Food Sci. 69(2):142-146 and Seyfert et. al. 2004. Internal premature browning in cooked ground beef from high oxygen modified atmosphere packaging. J. Food Sci. 69(9):721-725]. This phenomenon (where meat reaches a brown, ready-to-eat "safe" interior appearance at temperatures below that necessary to kill any pathogens that might be present) has much greater food safety risk than any of the low-oxygen packaging formats. In total, the CO-MAP format will deliver to consumers a higher, more consistent quality product that is safer for consumers who use cooked color as an indicator of doneness than what the hi-ox system has ever delivered. Consumers should champion the CO system for both its superior quality and safety.

Role of Color of Meat Products:
It seems critical to this controversy to comment on the historical and current role that color of meat plays in consumer acceptance of meat products. Both sides of this packaging issue correctly state that the color of meat is a major factor in consumer acceptance. The same can be said for nearly any food product and many non-food products. Packaging plays a critical role in determining the overall attractiveness (not just color) of a product, which is used by consumers to help make purchasing decisions. A major question is, what does meat color mean to consumers?

For some, color may mean freshness, to others it may mean better eating, some may know that muscles (that they like) vary naturally in redness and, for many, they just want to purchase meat that looks good. Historically, all would be correct. Meat from older animals, which is often less tender and of a different flavor, is darker – but this has nothing per se to do with meat safety or microbiology. Meat that appears red can be inferred to be fresh, but considering muscle chemistry, the purple-red color would more appropriately indicate muscle freshness, yet both of these colors can appear independent of the cut's microbiology. Vacuum packaged meat has been purchased by consumers for years and its color does not provide consumers any clues about safety or spoilage. The natural variation in color between muscles is completely independent of color clues for wholesomeness. The psychology of color acceptance to many people is much higher for the red hue of meat than would be the brown or dark purple hues that can occur in meat packages. Thus, people may "buy meat with their eyes", but they likely do it for different reasons. As with thousands of decisions made daily by consumers selecting food products, they are assuming that all products available for purchase are safe and of high quality.

Meat color is primarily affected by the gases it is exposed to and to the oxidative status of the heme iron in myoglobin. All of these reactions can occur in sterile meat or in meat with bacteria on its surface. However, there are a host of factors that influence these interacting parameters, not the least of which are packaging atmospheres and cold chain management. For over 50 years, US consumers have been purchasing meat in a variety of package formats that presents meat in various colors that cannot be interpreted to indicate freshness or spoilage. Some of the comments by critics of CO in meat packaging seem to partially or totally ignore the complexity of these factors in maintaining stable meat color without sacrificing meat quality. The issue of CO forming color that is "misleading to consumers and masking of spoilage" is bogus because (even though spoilage could be present) there is a much greater likelihood that meat color (good or bad) has essentially nothing to do with microbiology. The proposed CO packaging system is no more susceptible to microbial growth than any other packaging system, especially the high-oxygen system being compared to CO-MAP.

The bottom line here is that to infer meat color always reflects freshness and its state of spoilage is not accurate. Our whole food delivery system depends on standards of excellence, company reputation, and adherence to good food handling practices, including the responsibility of consumers. Consumers expect all meat products to be safe to cook and consume and that it is up to them to pass final judgment in the unlikely event that spoilage, independent of color indicators, has occurred.

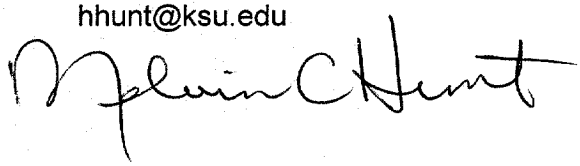
Our federal regulatory agencies have a tremendous record in evaluating new processing aids and technologies, including use of CO in modified atmospheres. FDA and USDA have practiced good scientific judgments in the past and there is no need to deviate from them on this packaging issue.

In conclusion:

1. The GRAS designation for the CO-low oxygen packaging system is justified.

2. CO is only one of many factors affecting meat color and appearance, and most of these factors exert their influence on pigment chemistry independent of microbial load – many examples exist where retail meat color is not a reliable indicator of spoilage.

3. Consumers use the color of meat as just one of several criteria for selection, and the inferences of color are used as much or more for quality expectations as they are for wholesomeness.

Melvin C. Hunt
Professor, Meat Science
Kansas State University
224 Weber Hall
Manhattan, Kansas 66506

785-532-1232
hhunt@ksu.edu