Current Research in Case-Ready

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Introduction

Quickly flip through packaging magazines and the various trade journals, and you will see a technology that is vying for space, case-ready fresh red meats. Look no further than their covers, and the sole topic seems to be "case-ready credentials," or "case-ready is here," or some such headline. Or when one accesses the Web on food packaging, reams of information can be quickly, and probably dangerously, generated on the various technologies that case-ready meats has to offer your day-to-day operation. Surprisingly, case-ready meats has been discussed and studied for more than 40 years for its potential to totally alter the meat industry.

Centralized packaging of fresh red meat – making the product "case-ready" – has and will continue to displace supermarket back-room fabrication and packaging, and deliver not just a meal ingredient, but a prepared food product which is ready-to-heat and eat, just as poultry did in the 80's as a result of improved technologies and distribution enhancement. Long ago poultry converted from its archaic delivery of whole birds in ice in wire crates to cut-up parts in over wrap film trays to today's boneless parts which are presented to consumers in barrier packages with internal modified atmospheres. Fresh pork has been actively converting its entire packaging process during this same time. Despite two decades of decline in per capita consumption, the beef industry has thrown its hat into the case-ready packaging arena in a big way. Each year in the U.S. approximately 31,000 supermarkets merchandise over 9 billion packages of fresh beef. This is a larger number of packages than for almost any other single food package category, reflecting the size of the target market for suppliers. And almost half of this is ground beef.

It is estimated that approximately 20% of all beef is case-ready, and most of this ground beef, meaning that up to 50% of the ground beef is centrally packaged. Certainly, the beef industry is in a "ramping-up" period in terms of case-ready packaging. With the industry's decision to go forward with case-ready, there has been more than 60 case-ready systems developed, probably 30 of which are in one or another way commercial today, and about a dozen that are in real commercial use in the U.S. Currently, the impression is that meat processors and retailers are confused by all of the claims and counter-claims made by suppliers with regard to product shelf life versus product quality. The big question is, "where is all of this going?" What technologies can be incorporated into current case-ready programs, which will improve the shelf life, flavor and safety characteristics of the current meat supply? The overall objective of this manuscript is to review some of the developmental quality shortcomings/issues that case-ready meat has encountered and provide some potential research solutions that have allowed science-based decisions to be made with regard to case-ready technologies.

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Recent Case-Ready Meat Challenges

Challenge #1: Off-Flavor and Mouth Feel Concerns

Research has shown that consumers consider tenderness to be the primary determinant of eating satisfaction. However, reports have also shown that lean color is the predominant factor affecting purchases. Naturally, the development of new products for the retail meat industry must strive to maintain meat color during display and provide a consistent and pleasurable eating experience when items are prepared and consumed at home. While this is a challenge, recent investigations have revealed that enhancing beef products with a solution of salt, sodium tripolyphosphate, and sodium lactate could improve the consistency and palatability of beef products (Vote et al., 2000). However, recently many consumer complaints and in turn retailer concerns with regard to "off-flavor" and "rubbery texture" associated with some enhanced beef products has been brought to the forefront. In an attempt to address some of these issues, Brooks and Morgan (2001) conducted a very encompassing project that included beef subprimals representing 12 retail beef cuts from USDA Select carcasses. Paired subprimal pieces were assigned to one of four treatment groups. The Oklahoma State University (OSU) treatments consisted of two enhancement levels (5% and 10%) and two enhancement solutions (Solution A and B). The ingredients for each treatment included varying levels of salt, sodium tripolyphosphate and Herbalox®. Serving as an industry control were beef retail cuts produced under the

Thomas E. Wilson® label which were obtained from a commercial processor. The retail cuts were subjected to Warner-Bratzler shear force, retail display, laboratory analysis, and trained sensory analysis. The data generated was used as a basis for statistical comparison between Thomas E. Wilson® and the four treatments identified in this study. Warner-Bratzler shear force values showed a distinct advantage in tenderness for OSU treatments over the Thomas E. Wilson product (Table 1). The results were more profound in steaks from the rib and loin. Steaks from the round tended to have shear force values similar to Thomas E. Wilson steaks, with at least one OSU treatment having an advantage in tenderness. The shear force values observed are similar to those seen in the 1998 National Beef Tenderness Survey (Brooks et al., 2000). Generally, steaks from the round do not respond to tenderness enhancing factors as well as steaks from the rib and loin. Research has identified a shear force threshold of 3.8 kg for consumer acceptance. Thus, steaks with a mean shear force of 3.8 kg (or less) have a tendency to be ranked as slightly tender (or better) when evaluated by trained sensory panelists. With the exception of the chuck tender, bottom round, inside round, and eye of round, steaks had acceptable shear force values.

Table 1. Least squares means of Warner-Bratzler shear force (kg) for each treatment.

	Treatment				
	A1	A2	B1	B2	TEW
Chuck Tender	3.8^{a}	4.0^{a}	4.6^{b}	3.9^{a}	5.2^{c}
Shoulder Clod	3.8^{a}	3.8^{a}	3.7^{a}	3.8^{a}	4.8^{b}
Ribeye	3.2^{a}	3.3^{a}	3.4^{ab}	3.5^{b}	5.3^{c}
Chuck	3.9^{a}	3.9^{a}	3.9^{a}	3.8^{a}	4.8^{b}
Strip Loin	3.5^{a}	3.3^{a}	3.8^{b}	3.9^{b}	4.3^{c}
Top Sirloin Butt	4.1^{c}	3.9^{b}	3.3^{a}	3.8^{b}	4.3^{c}
Knuckle	3.8^{ab}	3.7^{a}	3.8^{ab}	4.0^{b}	5.0^{c}
Bottom Round	5.1^{a}	5.1^{a}	6.0^{b}	5.7^{ab}	5.9^{b}
Top Blade	2.7^{a}	3.1^{bc}	2.9^{ab}	3.4^{d}	3.3^{cd}
Shortloin	3.2^{ab}	3.0^{a}	3.5^{bc}	3.6^{c}	4.4^{d}
Inside Round	4.7^{a}	4.7^{a}	4.6^{a}	5.4^{b}	5.1^{b}
Eye of Round	4.0^{a}	4.4^{b}	4.2^{ab}	4.3^{b}	5.2^{c}

[a,b,c,d]Within a row, means lacking a common superscript differ ($P < 0.05$).
Treatments: Solution A at 10% = A1, Solution A at 5% = A2, Solution B at 10% = B1, Solution B at 5% = B2, TEW = Thomas E. Wilson®

So, what is the take home message? What enhancement solution and level should be utilized in order to maximize palatability as well as shelf life characteristics? Typical university answer, "Well, it depends on which cut/muscle you're working with?" For example, information in Table 2 overviews the palatability and shelf life response of the ribeye and eye of round subprimals to various enhancement protocols.

Table 2. Optimum enhancement protocols for the ribeye and eye of round subprimals.

Trait	Ribeye Optimum treatment	Eye of Round Optimum treatment
Warner-Bratzler shear force	A1, A2, B1	A1, B1, B2
TBA, 0 d	B1, B2, A2	B2, A2, A1
TBA, 3 d	B1	B2, A1
TBA, 7 d	B1, B2	B2
Subjective lean color	B1, A1	B2, A2
Subjective fat color	A1, B1	A2, B2
Subjective percent discoloration	B1, B2	B2, A2
Subjective overall acceptability	B1, B2	B2, A2
Sensory Tenderness	A2, B1, B2	A1, B1
Sensory Juiciness	ALL	A1, A2
Sensory Salt	ALL	B1, B2
Sensory Soapy	ALL	ALL
Sensory Acceptability	ALL	A1, A2, B1
Enhancement Recommendation	**Solution B1**	**Solution A2**

Treatments: Solution A at 10% = A1, Solution A at 5% = A2, Solution B at 10% = B1, Solution B at 5% = B2

Challenge #2: Excessive Amounts of Packaging Materials

According to Wal-Mart personnel, one of the most consistent customer concerns with regard to their case-ready meat program is the great amount of package (tray and headspace) used for each retail cut. Certainly as you would expect Wal-Mart along with every other retailer would love to reduce the amount of headspace utilized in their case-ready meats. As a result of excessive headspace as well as large amounts of corrugated cardboard used to package case-ready packages, many inefficiencies accompany these programs. For example, the current four case-ready tray footprints utilized today do not fit the standard 40″x 48″ pallets very efficiently, leading to only 68% of the available area for the boxed case-ready packages being utilized. This has virtually led to approximately doubled shipping costs since only 22,000 pounds of case-ready products can be transported on a standard (40,000 pound capacity) refrigerated trailer. These shipping and distribution impasses have led to research that reduces the head space volumes while maintaining the bright cherry-red lean color of case-ready beef. The Map-Tech Corporation has conducted some unique case-ready packaging trials, which actually embeds oxygen into the interstitial spaces of meat that in turn allows for the headspace volume of the package to be virtually eliminated. This oxygen saturation process is accomplished by placing meat into a self-contained chamber. Once sealed in the chamber, meat is placed under pressure in the presence of pure oxygen that promotes oxygen uptake in the meat inner spaces. After approximately 20 minutes in this process, the meat is removed and placed into a shallow case-ready tray, the atmosphere is modified and the tray is lidded. Preliminary results appear to indicate that similar case life characteristics can be accomplished to that of standard case-ready systems.

Challenge #3: Freezing of Case-Ready Meat Products

According to Ken Parnell of Wal-Mart (Vice-President for Meat/Seafood/ Deli), stated that approximately 80% of Wal-Mart's case-ready product goes directly into the consumer's in-home freezer until meal preparation. Modified atmosphere packaging systems (MAP), however, were designed for fresh meat products. With that in mind, Payne et al. (2002) determined the influence of fresh and frozen storage on palatability, oxidative rancidity, and lean color of MAP beef steaks. Briefly, USDA Select ribeye rolls were injected with a solution (110% of their original weight) of salt, phosphate, and rosemary oleoresin (i.e., Herbalox®). Steaks were MAP packaged then assigned randomly to one of five storage treatments: 3 d in a household refrigerator (2.2ºC), 15, 30, 60, or 90 d in a household freezer (-14.4ºC).

The effects of storage on purge, weight loss, and amount of O_2 in packages are shown in Table 3. Storage had a significant effect on purge, weight loss, and amount of O_2. The amount of O_2 present in the packages tended to increase as frozen storage increased, but there were no significant difference among treatments. However, 3-d refrigerated packages had significantly less O_2 than their 15, 60, and 90 d frozen counter parts. Storage did have an affect on weight loss. Generally, longer storage times resulted in greater losses of moisture and in turn weight. Samples stored frozen for 90 d had higher purge amounts and weight loss compared to all other treatments. Weight loss and purge amounts were similar for samples stored in the refrigerator and freezer for 15 and 30 d.

Table 3. Effect of storage treatment on purge, weight loss, and oxygen in package atmosphere.

	Fresh	Frozen storage			
	3 d	15 d	30 d	60 d	90 d
Purge, mL	.56^{a}	2.44^{ab}	3.32^{ab}	5.10^{bc}	8.31^{c}
% O_2	72.27^{a}	73.57^{b}	73.27^{ab}	74.22^{b}	74.08^{b}
Weight loss, g	.36^{a}	.88^{ab}	1.20^{ab}	1.78^{bc}	2.20^{c}

$^{a, b, c}$ Least Square Means in a row lacking a common superscript letter differ (P<.05)

The effects of storage on the CIE color values are shown in Table 4. Values were taken at fabrication and at each storage time. There was a drastic increase in a* values after products were enhanced and packaged. Steaks stored in the refrigerator were similar to those stored in the freezer for 15 d. After 30-d of storage in the freezer, a* value declined significantly. The same phenomenon was observed for steaks stored in the freezer for 60 d, compared to their 30-d counterparts. CIE b* values were significantly lower at fabrication compared to all other storage treatments. Storage in the refrigerator for 3 d, in the freezer for 15 d or in the freezer for 30 d, had no effect on b* values. However, there was a significant decline in b* values as frozen storage was carried out to 60 and 90 d, when compared to other fresh and frozen storage treatments.

Table 4. The effects of storage on objective CIE color values.

		Fresh	Frozen			
	At Fab	3 d	15 d	30 d	60 d	90 d
L*	35.89^{a}	36.54^{a}	34.48^{ab}	33.70^{b}	35.83^{ab}	37.04^{a}
a*	17.68^{a}	25.20^{b}	24.99^{b}	22.75^{c}	18.79^{d}	17.26^{a}
b*	16.36^{c}	21.46^{a}	22.22^{a}	21.48^{a}	19.79^{b}	19.47^{b}

$^{a, b, c}$ Least Square Means in a row lacking a common superscript letter differ (P<.05)

One interesting aspect of this study was that oxidative end products were not influence by freezing. This is probably due to the addition of rosemary oleoresin (a powerful antioxidant) and the storage of products at frozen temperatures. It should be noted that panelists showed that there were no differences in product odor for samples stored in the refrigerator and up to 60 d in the freezer. However, odor was significantly detected after steaks had been stored frozen for 90 d. These data suggest that frozen storage of steaks beyond 90 d could have detrimental effects on odor.

Table 5. Effects of storage on odor characteristics of modified atmosphere packages.

	Fresh	Frozen storage			
	3 d	15 d	30 d	60 d	90 d
Odor[1]	2.14^{a}	2.6^{b}	2.24^{a}	2.2^{a}	3.65^{c}

$^{a, b, c}$ Least Square Means in a row lacking a common superscript letter differ (P<.05)

[1]2= Odor present, which activates smell but is not distinguishable; 3= Odor present, which activates smell, is distinguishable, not necessarily objectionable in short periods

Challenge #4: Utilizing Carbon Monoxide in Case-Ready Meat Products

In purchasing of fresh retail beef, the microbiological shelf-life, color and general appearance are important features to consumers. Underlying these features, food safety and product confidence has been increasingly emphasized. Growth of spoilage and pathogenic bacteria is generally reduced by stringent hygienic standards, low and consistent temperatures throughout delivery chain and by using MAP, the latter by increased levels of carbon dioxide (CO_2) and (or) removal of oxygen (O_2). Color of meat is very important at the point of purchase, and establishing and maintaining a bright cherry-red and attractive color during retail display is an ongoing challenge. Carbon monoxide (CO) has the ability to form a stable bright red of meat, even in very low concentrations. The color properties of CO were known over 100 years ago, when a patent on a CO_2/CO gas mixture for meat was granted. Today, in some European countries, much of the beef is packaged using a gas mixture consisting of CO (0.3% to 0.5%), CO_2 (60% to 70%) and nitrogen (30% to 40%). This low CO packaging has grown to a current market share of 60% of the Norwegian red meat industry.

A number of research reports have been published on packaging and treatment with atmospheres containing CO. The use of CO can be divided into three categories:

1. Packaged and stored in low CO concentrations (0.1% to 2.0% CO);
2. Packaged and stored in high CO concentrations (5.0% to 100.0% CO); and
3. Pretreatment with high CO concentrations, followed by vacuum packaging and storage.

It should be mentioned that the low CO concentration packaging systems were used mainly for improvement in lean color stability, whereas, color and antimicrobiological improvements were the goal of the high CO packaging systems. The main function of CO in MAP of meat is to make a stable, bright red color, as a result of the strong binding of CO to deoxymyoglobin and formation of carboxymyoglobin. The spectrum of carboxymyoglobin is very similar to that of oxymyoglobin (Tappel, 1957), but carboxymyoglobin is more resistant to oxidation (Lanier et al., 1978). CO in concentrations of one to five percent increased the reduction of metmyoglobin, even in the presence of air (Lanier et al., 1978). Without CO present, meat in CO_2/N_2 atmospheres is vulnerable to discoloration by myoglobin oxidation due to residual O_2, occurring in beef with less than 0.1% O_2 (Gill and McGinnis, 1995). Several studies have documented that low concentrations of CO – 0.1% to 2.0% – improved meat color and color stability. These reports included meat from beef, pork and poultry and color improvement by CO seemed to work and be valid if the other gases were CO_2, N_2, O_2 or air. When increasing CO concentration to 2.0%, the lean color was characterized as being "too artificial" by a sensory panel (Renerre and Labadie, 1993). Therefore, concentrations of 0.4% to 1.0% CO can be regarded as sufficient and suitable for color purposes in MAP of meat. Another approach for utilizing positive effects of CO on meat color is to pretreat fresh meat with CO, and maintain the bright red color by continued storage in vacuum packages (Brewer et al., 1994; Jayasingh et al., 2001).

The USDA has recently commented that CO can be used in a secondary meat packaging system (i.e., "mother-bag") and that any CO residue must be partially purged from the primary packaging container prior to the human consumption of these meat products. Most beef processors that we have visited with have stated that they do not want to use the CO technology in packaging systems that require a mother-bag. This can certainly be understood in that inefficiencies such as decreased weights per box and increased cost associated with greater volumes of gas mixtures of secondary packaging systems comes to mind. One packaging opportunity that has been investigated by the Meat Science Group at Oklahoma State University offers potential for CO incorporation and USDA requirements to be fulfilled (Stubbs et al., 2002). This system referred to as Cryovac Peelable Film® is being used by IBP in their Consumer Friendly® case ready ground beef program in that meat merchandisers just open the box, peel off the top layer of film, label, and merchandise. This low oxygen system has been successful in that it has potential to incorporate CO in order to improve shelf life and microbial characteristics of ground beef and other compromised beef cuts.

Conclusions and Implications

Once again, the big question regarding case-ready beef, "where is it all going?" I hesitate to forecast. Packaging experts say something to the effect that about 40% of all beef will be centrally packaged by 2005. Factors such as technology capabilities, current equipment placements, retailer adoption rates, economics, and red meat dynamics has lead to this estimate. One thing that is also mentioned in many packaging journals is that a portion of the market will be captured by one or more new and as yet unidentified technologies. Certainly, this means that food and packaging technologists might have some challenging research presented to them in the next few years.

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