RECIPROCAL MEAT CONFERENCE
EXCHANGE
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Advances in Muscle Biology and Meat Quality

Consumers experience meat quality through relatively simple attributes: how meat looks in the retail case and how it tastes when it reaches the plate. The biology responsible for color, tenderness, juiciness and flavor is far more complex. Increasingly, research is showing that these traits reflect interacting systems that begin with the live animal, continue through postmortem muscle metabolism and ultimately shape the consumer experience.

Quality Begins Before Slaughter

Animal health and stress can influence the biological starting point for meat quality. Heart and liver health, cattle type and environmental stress have all been associated with subsequent carcass and meat-quality characteristics. Severe heart remodeling has been associated with reduced marbling, while liver health can affect marbling and color. Heat waves and cold snaps can also degrade quality and increase the risk of dark cutting.

Dark cutting illustrates this connection. Extended preslaughter stress can deplete muscle glycogen reserves, limiting normal postmortem pH decline and altering meat color. Emerging work also suggests that not all darker lean represents the same biological condition. In dairy-cross cattle, for example, darker lean may potentially be misclassified as traditional dark-cutting beef. Aging, cattle type and liver health can also interact in their effects on retail color.

Why this research matters: Understanding the biological condition of the animal may help explain quality variation that cannot be addressed through postharvest interventions alone.

Postmortem Muscle Is More Dynamic Than We Thought

The traditional explanation of postmortem metabolism focuses heavily on glycogen conversion to lactate, declining pH and development of rigor. Newer work shows that postmortem muscle remains considerably more dynamic.

Changes in gene expression have been observed well after slaughter, including genes becoming more highly expressed 48, 72 and even 96 hours postmortem. Chilling conditions can influence the timing of those changes. Metabolomics also suggests that as carbohydrate metabolism changes, postmortem muscle may increasingly draw upon lipids and amino acids as energy sources.

That complexity helps explain why identifying a biomarker associated with meat quality does not necessarily make it a reliable predictor. Relationships among proteins, metabolites and quality traits can change depending on what else is occurring in the muscle. In one example, the relationship between peroxiredoxin

and tenderness changed when oxidative damage was considered. Looking at the biomarker independently obscured part of the biological interaction.

The larger challenge is moving from biomarker discovery to understanding how pathways work together. Multi-trait studies, broader validation and collaboration across research groups will be needed to translate increasingly detailed omics data into useful quality prediction.

Why this research matters: The next advances in meat quality may come less from finding another individual biomarker and more from understanding how multiple pathways interact.

From Muscle Biology to the Eating Experience

The ultimate test of meat quality is the experience it delivers to the consumer. Dunshea's work on an Australian pork eating-quality model illustrates how many factors can converge to shape that experience.

The model incorporates biological and processing factors ranging from sex, pH and aging to cut, cooking method and endpoint temperature, and correctly classified 64.5% of samples into the appropriate consumer eating-quality category. Other Australian consumer research presented by Dunshea showed that flavor contributed about 60% of overall liking, substantially more than tenderness.

The model also points toward what remains to be learned. Intramuscular fat, collagen content and collagen solubility are potential additions, and new technologies may eventually allow more of these biological characteristics to be measured and incorporated into quality prediction.

Discussion of pork research priorities reinforced the challenge. Marbling and color have relatively weak relationships with pork loin tenderness, juiciness and flavor, while endpoint cooking temperature can have a much larger influence on eating quality.

Why this research matters: Connecting muscle biology with consumer eating quality can shift the focus from measuring individual traits to predicting the experience a product will deliver.

Color Is Biology Consumers Can See

Color provides one of the clearest links between underlying biology and consumer response. Shoppers begin discriminating against beef with relatively modest discoloration. At about 20% surface discoloration, purchase decisions can already be affected, and by roughly 40%, consumers largely reject the product. The consequences include discounting, discarded product and lost value.

Research into spoilage organisms adds another layer to our understanding of meat color. Beef with very low microbial loads was compared with steaks inoculated with spoilage organisms isolated from meat, including *Pseudomonas* and lactic acid bacteria. Differences in discoloration became increasingly evident as retail display progressed. Responses also differed between the relatively color-stable longissimus and color-labile psoas major, reinforcing that microbial growth, muscle characteristics and color chemistry interact.

New optical approaches are also expanding how those changes can be evaluated. Non-contact diffuse reflectance spectroscopy and optical coherence tomography are being explored to characterize changes in myoglobin and muscle structure, creating opportunities to assess color objectively without physically contacting the meat surface.

Why this research matters: Better understanding and measurement of the biology driving discoloration could extend product value, reduce waste and improve objective quality assessment.

Connecting the System

Together, these advances point toward a more integrated view of meat quality. Animal health and stress establish biological conditions before slaughter. Postmortem muscle continues to undergo complex metabolic changes. Those pathways interact to influence color, tenderness, flavor and other quality traits, while processing and preparation further shape the final experience.

The opportunity is to connect those pieces well enough to move from describing quality after it occurs to predicting and managing the biology that produces it. Doing so will require muscle biology, omics, consumer science and measurement technologies to work together rather than treating individual quality traits as isolated outcomes.

Conference Presentations Featured in this Article

This article synthesizes presentations and discussions from the Meat and Muscle Biology track at the 2026 Reciprocal Meat Conference, including contributions from Ben Bohrer, Ph.D., Yan Campbell, Ph.D., Frank Dunshea, Ph.D., Megan Eckhardt, Ph.D., Jessica Higgins, Ph.D., Andy King, Ph.D., Mahesh Nair, Ph.D., and Daqing Piao, Ph.D.

About RMC Exchange

RMC Exchange extends the value of the Reciprocal Meat Conference by synthesizing research and discussions from multiple presentations into topic-focused articles. Each feature connects the science, highlights emerging trends, and explores the practical applications advancing meat science and the meat industry.