

# Project Summary

## The Effects of Metabolites on Beef Color

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### Background

Maintenance of fresh beef color is critical for consumer satisfaction. Case-ready technology provides an opportunity to enhance meat with various ingredients that have the ability to influence color life. Lactate is added to case-ready meat and is often described as a color stabilizer in fresh beef. Other metabolites, such as pyruvate and succinate, can influence postmortem muscle chemistry and therefore, have the potential to improve beef color stability.

### Methodology

In experiment 1, the effects of pyruvate on bovine mitochondrial oxygen consumption and metmyoglobin reduction were assessed. Mitochondria (3 mg/mL) and metmyoglobin (0.15 mM) were reacted with pyruvate (50 mM) and succinate (positive control; 50 mM) and oxygen consumption was measured using a Clark oxygen electrode. Metmyoglobin (2.5 mg/mL) reduction was measured at specific time points; samples were centrifuged and the resulting supernatant was scanned from 650 to 500 nm to determine the relative proportions of deoxymyoglobin, oxymyoglobin and metmyoglobin.

In experiment 2, beef strip loins were divided into two halves, and each half was randomly assigned to one of four injection enhancements: 1) non-enhanced control; 2) 3% pyruvate, 3) 3% succinate, and 4) 3% lactate (3% refers to the finished product). From each loin, steaks were cut and packaged in either vacuum, high-oxygen (80% O<sub>2</sub>/20% CO<sub>2</sub>), or polyvinyl chloride (PVC) overwrap. Packages were stored at 1°C and color and lipid oxidation were measured on days 0, 5 and 13 of storage. Color measurements included redness ( $a^*$ ), darkening ( $L^*$ ) and metmyoglobin reducing activity. Lipid oxidation was measured using thiobarbituric acid reactive substances (TBARS).

### Findings

Experiment 1: Succinate and pyruvate increased oxygen consumption and metmyoglobin reduction, both of which are directly related to beef color stability. Results from the current study suggest that metabolites such as pyruvate and succinate have the potential to influence both beef color and postmortem muscle chemistry by increasing the ability of mitochondria to consume oxygen and reduce metmyoglobin.

Experiment 2: Loins enhanced with lactate, pyruvate and succinate were more red than non-enhanced steaks in PVC and high-oxygen packaging at the end of storage (day 13). In general, lactate-enhanced steaks in high-oxygen and PVC tended to be the least discolored. Regardless of packaging type, injection-enhancement darkened steaks, with pyruvate resulting in the most surface darkening. In addition, succinate had the greatest and pyruvate had the least metmyoglobin reducing activity during storage (succinate > lactate > control > pyruvate). There was no effect of injection-enhancement on lipid oxidation of steaks packaged in vacuum whereas lactate and pyruvate reduced the lipid oxidation of steaks packaged in PVC. All three injection-enhancement treatments decreased lipid oxidation in high-oxygen packaging, with pyruvate being the most effective.

## Implications

This research suggests that postmortem substrate depletion influences processes associated with beef color, in particular, oxygen consumption and metmyoglobin reducing activity. As a result, the incorporation of metabolites such as lactate, pyruvate and succinate into beef using case-ready technologies has potential to improve color life and decrease lipid oxidation. This is likely because these ingredients alter postmortem muscle chemistry and metabolism, possibly producing reducing equivalents and other components necessary to maintain desirable color. In the current study, both the fundamental research using model systems and the applied research using beef loins provide a solid foundation to investigate other natural metabolites as ingredients intended to improve beef shelf life.

Effects of enhancement and packaging on the a\* values (redness) of beef *longissimus* steaks stored for 13 days at 1 °C. A greater a\* value indicates more red color.

Storage	Enhancement	Packaging		
		Vacuum	PVC	HiOx
0 days	Control	29.5	29.5	29.5
9 days	Control	20.0	23.9	25.9
	Pyruvate	10.7	21.1	25.6
	Succinate	22.8	22.4	26.3
	Lactate	21.4	23.1	26.4
13 days	Control	18.4	16.7	21.3
	Pyruvate	13.5	19.9	22.9
	Succinate	23.5	18.1	24.1
	Lactate	22.4	20.5	26.3

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