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Impact of Stress Physiology on Meat Quality in Livestock

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ARTICLE HISTORY

Received: April 26, 2025

Accepted: April 29, 2025

Published: April 30, 2025

Abstract

Stress in livestock significantly impacts meat quality through physiological and biochemical pathways, primarily via the activation of the hypothalamic-pituitary-adrenal (HPA) and sympathetic-adrenal-medullary (SAM) systems. These responses alter energy metabolism and muscle chemistry, affecting post-mortem processes such as pH decline and rigor mortis. Chronic and acute stress can lead to meat defects like DFD (Dark, Firm, Dry) and PSE (Pale, Soft, Exudative), compromising tenderness, water-holding capacity, appearance, and shelf life. Species-specific responses, handling practices, and pre-slaughter conditions further influence outcomes. Implementing mitigation strategies—such as gentle handling, optimal lairage, and regulated chilling—can improve meat quality and promote animal welfare. Understanding stress physiology is essential for refining production practices and ensuring high-quality, ethically sourced meat products.

DOI: https://doi.org/10.5281/zenodo.15341038

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Keywords: Stress physiology, Meat quality, Rigor mortis, DFD and PSE meat, Animal welfare

Introduction

Stress in animals is a biological response to internal or external stimuli that threaten homeostasis. The stress felt by livestock plays an important role that affect the quality of meat products. The physiological reactions that occur due to stress before and during slaughter can result in biochemical alterations in muscle tissue, lead to biochemical changes in muscle tissue which in turn affect the meat's color, ability, water holding capacity, shelf life, and general consumer needs. Grasping the relationship between stress physiology and meat quality is vital for enhancing animal welfare, refining production methods, and ensuring the best quality meat products within the livestock sector.

Common reasons for stress in livestock include:

- Rough handling
- Transportation
- Overcrowding
- Over Fasting
- Heat stress
- Novel environments

These activate the hypothalamic-pituitary-adrenal (HPA) axis and sympathetic-adrenal- medullary (SAM) system, resulting in the release of glucocorticoids (cortisol) and catecholamines (adrenaline, noradrenaline).

This hormonal surge affects energy metabolism, muscle activity, and immune status, setting the stage for post-mortem meat quality issues.

Biochemical Consequences on Meat

After slaughter, muscle tissue undergoes a series of changes as it transitions to meat. One of the most critical factors is the decline in pH, caused by the accumulation of lactic acid as muscle glycogen is broken down anaerobically.

In Healthy Animal → Slaughter → Muscle to Meat Conversion → pH Decline (Normal: 7.0 → 5.5) →

Tender Meat, flavorful meat with good water-holding capacity

If Chronic Stress → Low Glycogen → Less Lactic Acid → High pH (>6.0) → DFD Meat (Dark, Firm, Dry) in Beef, less visually appealing, more prone to microbial spoilage, and has a shorter shelf life.

If Acute Stress → Rapid pH Drop + Warm Carcass → Protein Denaturation → PSE Meat (Pale, Soft, Exudative) in pig, poor texture and reduced water-holding capacity, which can lead to weight loss during processing and cooking

Role of Rigor Mortis in Meat Quality

Rigor mortis is the stiffening of muscles after death due to the depletion of ATP, which is required to break actin-myosin cross-bridges in muscle fibers. Its timing and conditions directly affect meat tenderness and structure.

Normal Process: *Gradual ATP depletion → mild contraction → tender meat*

Delayed Rigor (due to chronic stress): Low glycogen → slow pH decline → incomplete rigor→ tough texture Accelerated Rigor (due to acute stress): Rapid pH drop + high temperature → protein denaturation → pale, soft, watery meat

Thus, the rate of pH fall and muscle temperature during rigor mortis are critical in determining final meat quality. Proper chilling regimes and stress management are essential to prevent tough, dry meat caused by improperly timed rigor mortis.

Species-Specific Responses

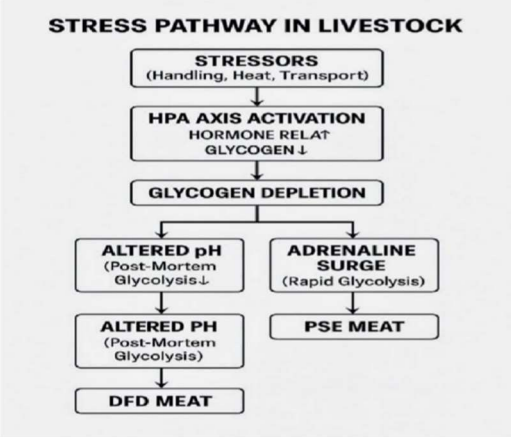
Different livestock species show varying sensitivity to stress, and thus the effect on meat quality can vary:

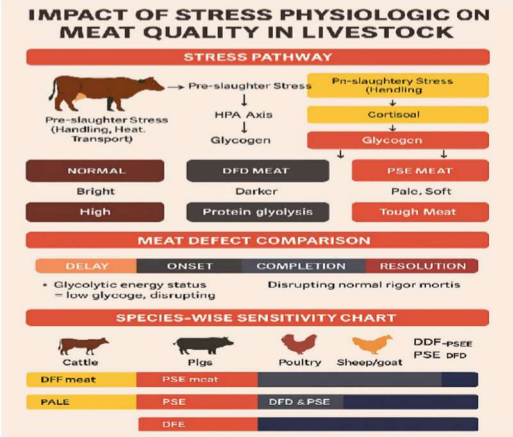
Species	Common Meat Issue	Notes
Cattle/Buffalo	DFD Meat	Handling practices, chronic stress
Pigs	PSE Meat	Acute stress
Poultry	PSE + bruising	High sensitivity to handling, rapid metabolism
Sheep/Goat	Both DFD and PSE	Depend on breed and handling

*Bruising means damage to a bird's skin and underlying tissues caused by physical trauma

Mitigation Strategies

i. Gentle handling practices
ii. Proper lairage (rest) time
iii. Efficient stunning and slaughter
iv. Optimized chilling methods to regulate rigor mortis
v. Staff Training
vi. Genetic selection for docile breeds
vii. , Improving animal welfare





Conclusion

Stress physiology plays a very important role in determining meat quality in livestock. Recognizing how an animal's physiological reaction to stress affects post-mortem muscle chemistry enables producers to adopt better practices for handling, transportation, and slaughter. By minimizing stress throughout all production stages, the industry can achieve higher quality meat, extended shelf life, and greater consumer satisfaction, all while fostering humane treatment of animals.

By reducing stress and comprehending the significance of rigor mortis, producers can enhance tenderness, visual appeal, and shelf life while encouraging ethical animal husbandry

References

Ferguson, D.M., & Warner, R.D. (2008). Pre-slaughter stress and meat quality in ruminants. Meat Science, 80(1), 12–19.

Hambrecht, E. *et al*. (2005). Pre-slaughter handling

effects on pork quality. Journal of Animal Science, 83(4), 900–907.
Lawrie, R.A. & Ledward, D.A. (2014). Lawrie's Meat Science, 8th Ed., Woodhead Publishing. Kondaiah, P. *et al*. (2012). Meat production and processing in India: Current status and future outlook. Indian Journal of Animal Sciences, 82(2), 123–128.
Rajkumar, A.S. *et al*. (2021). Physiological biomarkers and stress mitigation strategies in livestock. Journal of Veterinary Physiology, 15(1), 45–50.
Ramana, B.V. *et al*. (2019). Handling stress and its impact on buffalo meat quality. NRC on Meat Reports.
Warriss, P.D. (2010). Meat Science: An Introductory Text. CABI.

Contributions by Indian Scientists

Several Indian researchers have significantly contributed to this domain:
Dr. A.S. Rajkumar (ICAR-NIANP): Studied stress markers in livestock and their influence on product quality.
Dr. B.V. Ramana (ICAR-NRCM): Research on pre-slaughter handling and physiological stress response in Indian livestock.
Dr. P. Kondaiah (Formerly at ICAR-NRC on Meat): Pioneered meat quality improvement protocols in Indian buffalo and goat meat.
Dr. V.K. Modi (ICAR-CIFT): Worked on biochemical aspects of muscle-to-meat conversion under stress conditions.

References

1. Ferguson, D.M., & Warner, R.D. (2008). Pre-slaughter stress and meat quality in ruminants. Meat Science, 80(1), 12–19.
2. Hambrecht, E. et al. (2005). Pre-slaughter handling effects on pork quality. Journal of Animal Science, 83(4), 900–907.
3. Lawrie, R.A. & Ledward, D.A. (2014). Lawrie's Meat Science (8th Ed.). Woodhead Publishing.
4. Rajkumar, A.S. et al. (2021). Physiological biomarkers and stress mitigation strategies in livestock. Journal of Veterinary Physiology, 15(1), 45–50.
5. Ramana, B.V. et al. (2019). Handling stress and its impact on buffalo meat quality. NRC on Meat Reports.

Cite this article:
Aditi Choudhary, Dushyant Kumar. (2025). Impact of Stress Physiology on Meat Quality in Livestock. The Scientific Frontiers, 02(04), 4–6. https://doi.org/10.5281/zenodo.15341038.