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Beef Longissimus Lumborum Steak pH Affects External Bioelectrical Impedance Assessment

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Beef Longissimus Lumborum Steak pH Affects External Bioelectrical Impedance Assessment

Abstract

Objective: To use external bioelectrical impedance analysis to assess postmortem chemical changes in normal- and high-pH beef longissimus lumborum steaks during simulated retail display.

Study Description: Beef strip loins (n = 20; postmortem age = 14 d) obtained from a commercial processor were sorted into two treatments, normal-pH (5.61–5.64; n = 11) and high-pH (6.2–7.0; n = 9). Loins were fabricated into five 1-inch thick steaks (n = 100), and randomly assigned to one of five display days: 1, 3, 5, 7, and 9. External bioelectrical impedance values, oxygen consumption, metmyoglobin reducing ability, protein degradation, water holding capacity, and pH were assessed on each storage day.

The Bottom Line: External bioelectrical impedance is a method that could be used to separate normal- and high-pH strip loins with potential for rapid, in-plant use to identify dark-cutting beef.

Keywords

Beef, external electrical impedance, pH, postmortem

Authors

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Abstract

Postmortem chemical changes in normal- and high-pH beef strip loins (n = 20; postmortem age = 14 days) were assessed using external bioelectrical impedance during simulated retail display. Beef strip loins obtained from a commercial processor were sorted into normal- (n = 11) and high-pH (n = 9) treatments. Loins were fabricated into five 1-inch thick steaks and randomly assigned to one of five display days: 1, 3, 5, 7, and 9. External bioelectrical impedance, oxygen consumption, metmyoglobin reducing ability, protein degradation, water holding capacity, and pH were measured. There was a meat-pH × display day interaction for water holding capacity, pH, and oxygen consumption ($P < 0.05$). There was no meat-pH × display day interaction ($P < 0.05$) for external bioelectrical impedance or metmyoglobin reducing ability values; however, an effect on meat-pH and on display day was observed ($P < 0.05$). Intact and degraded desmin was 33% and 43% higher ($P < 0.05$), respectively, in normal-pH beef than high-pH beef. The meat-pH × display day interaction was marginally significant ($P = 0.0601$) for troponin-t 40 KDa. External bioelectrical impedance was moderately correlated with water holding capacity, oxygen consumption, and metmyoglobin reducing ability ($r = 0.35$; $P < 0.05$) and negatively correlated with pH ($r = -0.48$; $P < 0.05$) in high-pH beef. In normal-pH beef, external bioelectrical impedance was moderately correlated with water holding capacity, degraded troponin-t, and degraded portion ($r = 0.28$; $P < 0.05$) and negatively correlated with pH, intact and degraded desmin, and intact and degraded troponin-t ($r = -0.24$; $P < 0.05$). External bioelectrical impedance is a method that could be used to separate normal- and high-pH strip loins with potential for rapid, in-plant use to identify dark-cutting beef.

Introduction

Meat is a highly perishable commodity which naturally contains myoglobin, a protein responsible for the red color of fresh beef. Meat color is unstable, but is considered one of the major criteria for consumers when selecting meat purchases (Kropf, 1993). Bioelectrical impedance, a non-destructive analysis, was first documented for use by medical sciences in the early 1900s (Morse, 1925). Later, Swatland (1985) used electrical impedance to evaluate the relationship between the quality of pork carcasses and its electrical properties. Bioelectrical impedance analysis has been demonstrated to provide an accurate fat content determination in different pork and beef grinds; however, the smaller the grind size (1/8-inch plate), the more accurate bioelectrical impedance analysis was for predicting fat content (Marchello et al., 1999). In this study, external bioelectrical impedance analysis was used to assess postmortem chemical changes in normal- and high-pH beef *longissimus lumborum* steaks during simulated retail display.

Experimental Procedures

The experiment was designed as a split-plot with loin as the whole-plot and paired steaks as the sub-plot. Display day was treated as the sub-plot treatment. Meat-pH and display day were treated as fixed effects. Beef strip loins (n = 20; Institutional Meat Purchase Specifications #180) were obtained from a commercial processor (post-mortem age = 14 days). Loins were sorted into two treatments, normal-pH (5.61–5.64; n = 11) and high-pH (6.2–7.0; n = 9), fabricated into five 1-inch thick steaks (n = 100), and randomly assigned to one of five display days: 1, 3, 5, 7, and 9. Steaks were packaged on Styrofoam trays with a moisture absorbent pad, overwrapped with polyvinyl chloride film, and displayed under fluorescent lighting (32 W Del-Warm White 3000° K; Philips Lighting Co., Somerset, NJ) at 32–40°F in coffin-style retail cases (model DMF 8; Tyler Refrigeration Corp., Niles, MI) in the Kansas State University Color Laboratory. External bioelectrical impedance values, oxygen consumption, metmyoglobin reducing ability, protein degradation, water holding capacity, and pH were assessed on each storage day.

Results and Discussion

There was no meat-pH × display day interaction ($P > 0.05$) for external bioelectrical impedance values; however, an effect on meat-pH and display day was found ($P < 0.05$). External bioelectrical impedance was 20% higher ($P < 0.05$; Figure 1) for high-pH meat than normal-pH meat. As seen in Figure 2, steaks on day 1 had lower external bioelectrical impedance values ($P < 0.05$) compared to days 5 and 7, but similar ($P > 0.05$) to days 3 and 9.

There was no meat-pH × display day interaction ($P > 0.05$) for metmyoglobin reducing ability values; however, an effect on meat-pH and display day was found ($P < 0.05$). The metmyoglobin reducing the ability of high-pH meat was increased by 12% ($P < 0.05$) in comparison with normal-pH meat. Metmyoglobin reducing ability increased ($P < 0.05$) over the 9 days of retail display. There was no meat-pH × display day interaction ($P > 0.05$) or display day effect for intact or degraded desmin, however, a meat-pH effect ($P < 0.05$) was found. Normal-pH meat had 33 and 43% higher ($P < 0.05$) amount of intact and degraded desmin, respectively, than high-pH meat. The meat-pH × display day interaction was marginally significant for troponin-t 40 and 30 KDa ($P = 0.0601$). In addition, no meat-pH × display day interaction ($P > 0.05$) was found for troponin-t 36, 34, and 30 KDa.

In high-pH beef, external bioelectrical impedance values were moderately correlated with water holding capacity, oxygen consumption, and metmyoglobin reducing ability ($r = 0.35$; $P < 0.05$; Table 1). Additionally, a negative correlation occurred between external bioelectrical impedance and pH ($r = -0.48$; $P < 0.05$). External bioelectrical impedance was moderately correlated with water holding capacity, degraded troponin-t (30 KDa), and degraded portion (r = 0.28; P < 0.05; Table 2) for normal-pH beef. External bioelectrical impedance values were negatively correlated with pH, intact and degraded desmin, and intact and degraded troponin-t (36 KDa) (r = -0.24; P < 0.05).

Implications

External bioelectrical impedance is a method that could be used to separate normal- and high-pH strip loins with potential for rapid, in-plant use to identify dark-cutting beef.

References

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Table 1. Correlation coefficients between electrical measurements[1] of high-pH beef *longissimus lumborum* steaks and water holding capacity, pH, oxygen consumption, metmyoglobin reducing ability, desmin, troponin-t, and degraded portion

	Water holding capacity	pH	Oxygen consumption	Metmyoglobin reducing ability	Desmin[2] KDa		Troponin-T[3] KDa				Degraded portion[4]
					55	38	30	34	36	40	
R	0.28	0.40*	-0.17	-0.05	0.06	0.07	-0.16	0.28	0.04	0.23	0.18
X_c	0.37*	0.47***	-0.28	-0.33*	0.19	0.20	-0.10	0.27	0.02	0.08	0.09
Z	0.35*	-0.48**	0.56***	0.48**	-0.17	-0.23	0.12	-0.08	0.04	0.12	0.14

*P < 0.05.
**P < 0.01.
***P < 0.001.
[1]R = resistance; X_c = reactance; Z = impedance ($Z = X_c + R^2/X_c$).
[2]Intact desmin (55 KDa); degraded desmin (38 KDa).
[3]Intact troponin-t (40 KDa); degraded troponin-t (30, 34, and 36 KDa).
[4]Degraded portion = degraded desmin + degraded troponin-t.

Table 2. Correlation coefficients between electrical measurements[1] of normal-pH beef *longissimus lumborum* steaks and water holding capacity, pH, oxygen consumption, metmyoglobin reducing ability, desmin, troponin-t, and degraded portion

	Water holding capacity	pH	Oxygen consumption	Metmyoglobin reducing ability	Desmin[2] KDa		Troponin-T[3] KDa				Degraded portion[4]
					55	38	30	34	36	40	
R	0.26*	-0.06	-0.16	-0.05	0.01	0.06	0.33*	0.11	-0.20	0.14	0.01
X_c	0.21	0.55***	-0.29*	-0.27*	0.07	-0.27*	-0.18	0.01	0.15	0.47*	0.22
Z	0.28*	-0.37**	0.14	0.20	-0.24*	-0.31*	0.41**	-0.08	-0.30*	-0.43*	0.36**

*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.
[1]R = resistance; X_c = reactance; Z = impedance ($Z = X_c + R^2/X_c$).
[2]Intact desmin (55 KDa); degraded desmin (38 KDa).
[3]Intact troponin-t (40 KDa); degraded troponin-t (30, 34, and 36 KDa).
[4]Degraded portion = degraded desmin + degraded troponin-t.

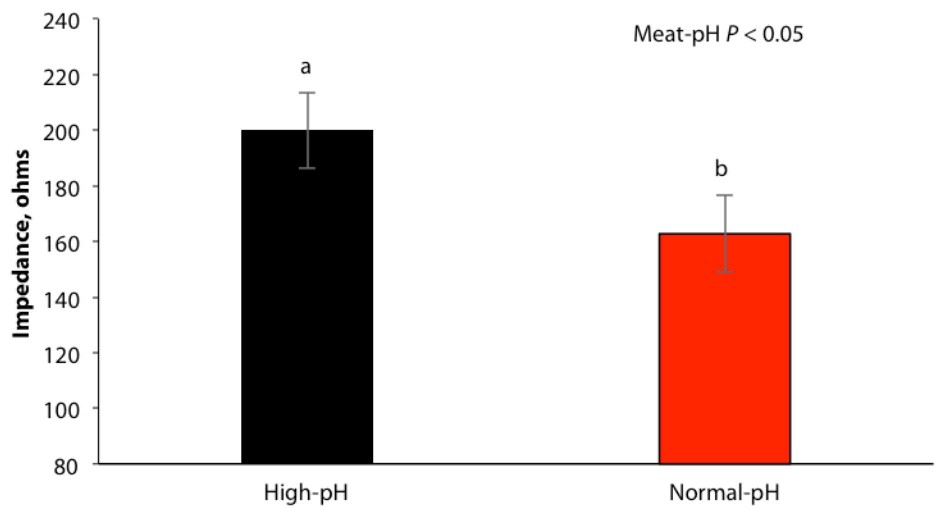

Figure 1. External bioelectrical impedance values of high-pH and normal-pH beef *longissimus lumborum* steaks.
[ab]Means with different superscripts differ ($P < 0.05$).

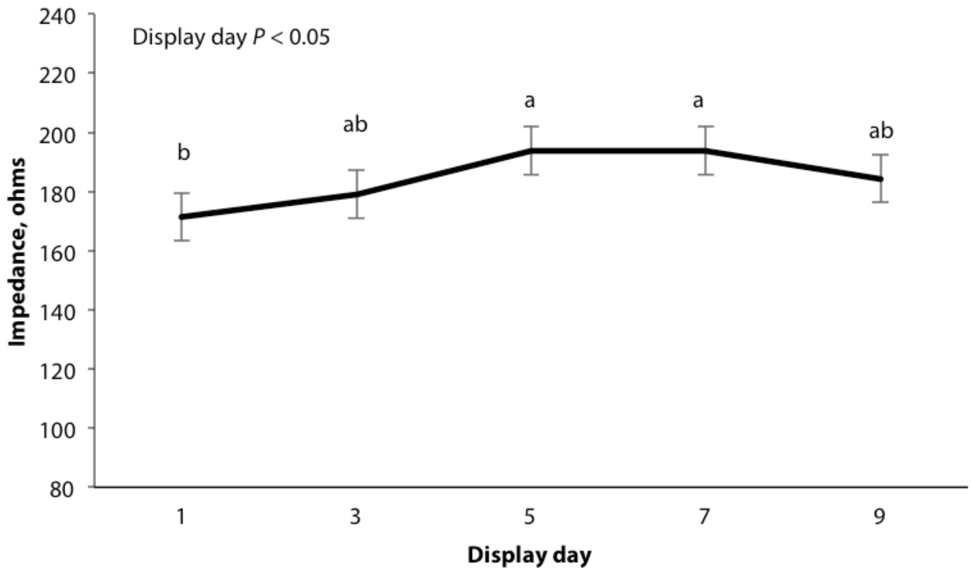

Figure 2. External bioelectrical impedance values of beef *longissimus lumborum* steaks displayed under fluorescent lights at 32-40°F for up to 9 days.
[ab]Means with different superscripts differ (P < 0.05).