BETA-ADRENERGIC AGONIST EFFECTS ON THE FRESH AND COOKED MEAT PROPERTIES OF AGED LONGISSIMUS LUMBORUM STEAKS FROM CALF-FED HOLSTEIN STEERS

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Abstract – The objective of this research was to characterize the effects of zilpaterol hydrochloride (ZH), ractopamine hydrochloride (RH), or no-beta-adrenergic agonist (β-AA; CON) supplementation on raw longissimus steak composition, pH, and color. Additionally, the internal color of cooked longissimus steaks aged for 14 or 21 d postmortem was evaluated. Protein content was greater (*P* < 0.01) and collagen content was lower (*P* = 0.04) in steaks from ZH-fed cattle when compared to CON. Raw ZH steaks were a less vivid red (lower *a and saturation index values; *P* < 0.01) compared to RH and CON steaks, which were not different. Trained panelist evaluations (*P* < 0.01) and Hunter *a** values (*P* = 0.07) indicated the internal cooked surface of ZH and RH steaks tended to be less red than CON. Although supplementation with β-AA altered the proximate composition and pH of calf-fed Holstein longissimus steaks, the statistical differences observed in raw and cooked color have limited practical implications.**

Key Words – beef, ractopamine hydrochloride, zilpaterol hydrochloride

I. INTRODUCTION

Approximately two-thirds of the 3.5 to 4 million Holstein steers born each year in the United States enter the fed beef market, comprising roughly 8 to 10% of the total market [4]. Though some suggest palatability advantages of calf-fed Holsteins compared to beef steers, decreased cut yields and subprimal conformation challenges often limit their utilization in beef retail and foodservice. Prior research has shown that growth promotion technologies, especially the beta-adrenergic agonist (β-AA) zilpaterol hydrochloride (ZH), may alleviate the conformation, muscling, and yield issues predominate in calf-fed Holstein steers [6, 14]. The palatability, tenderness, and raw color of steaks from calf-fed Holsteins fed ZH has been investigated [5]; however, comments from the foodservice industry suggest calf-fed Holstein steaks have a redder internal color after cooking. To our knowledge, no evaluations of the effects of β-AA supplementation on the cooked properties of calf-fed Holsteins exist. Therefore, the objectives of this research were to determine the effects of ZH and ractopamine hydrochloride (RH) supplementation on the proximate composition, pH, and raw and cooked color of mechanically portioned longissimus steaks from calf-fed Holstein steers.

II. MATERIALS AND METHODS

A. Cattle feeding and carcass selection.

Calf-fed Holstein steers (n = 565) were designated to one of three treatments: ZH (8.3 mg/kg of DM for 20 d followed by 3-4 d withdrawal; Merck Animal Health, DeSoto, KS, USA), RH (300 mg/kg for 28 d; Elanco Animal Health, Greenfield, IN, USA) or CON. One d post-harvest, carcasses grading USDA Choice were randomly selected to evenly represent treatments. Two d after harvest, the strip loins (longissimus lumborum, IMPS #180; n = 315) were removed from each carcass, vacuum packaged, and transported to the Texas Tech University Meat Laboratory (Lubbock, TX, USA). Strip loins were stored in the absence of light at 2 to 4°C until portioning.

B. Mechanical Portioning.

At 14 d postmortem, strip loins were faced and five 2.54-cm steaks were removed from the anterior end using a Marel Portioning Machine (IPM-3, Marel Townsend, Des Moines, IA, USA). The remainder of the strip loin was portioned into 11 oz. steaks. After portioning, the anterior most steak was reserved for analysis of raw color, proximate composition, and pH. Two additional steaks from the strip loin were vacuum packaged and aged for either 14 or 21 d postmortem. At their respective aging time, the steaks were frozen (-20°C) and stored until cooking.

C. Raw Color Analysis.

The steak reserved for raw color analysis was allowed to oxygenate, or "bloom", at 2 to 4°C for approximately 10 min after portioning. After the bloom period, instrumental color measurements were obtained at three locations on the steak surface using a portable Minolta colorimeter (Minolta Camera Co., LTD, Osaka, Japan) with illuminant A for CIE L^*, a^*, b^* values, a standard observer angle of 10°, and a one-cm diameter aperture. The CIE L^*, a^*, b^* values were used to calculate hue angle ($\tan^{-1} b^*/a^*$) and saturation index [$(a^{*2} + b^{*2})^{1/2}$]. The three observations from each steak were averaged prior to statistical analysis. After scanning, the steak was vacuum packaged and frozen (-20°C) for analysis of composition and pH.

D. Proximate Composition and pH.

Steaks for proximate analysis were thawed, trimmed of external fat, and ground using a commercially available grinder (Kitchen Aid, model KP26Mixer Professional 600, USA) to obtain a 200 g sample. Compositional analysis (fat, moisture, protein, and collagen) was conducted using an AOAC-approved (Official Method 2007.04) near-infared spectrophotometer (FOSS FoodScan™ 78800; Dedicated Analytical Solutions, Hilleroed, Denmark). At grinding, a 10-g sample was reserved for analysis of pH using the methods described by Luque et al. [8].

E. Cooked Color Analysis.

Thawed steaks were cooked on a belt grill (model TBG-60 Magigrill, Magi-Kitch'n Inc., Quakertown, PA, USA) to achieve an internal temperature of 70°C. The time and temperature upon removal from the grill were recorded and the medial portion of the steak was removed and allowed to rest at room temperature for 10 min. Following the 10 min rest period, the outermost 1-cm was trimmed to expose the interior surface for instrumental and subjective evaluation of cooked color. Trained color panelists (n = 3) evaluated the exposed internal cooked surface of the steak using the following: 1 = very red, 2 = medium red, 3 = pink, 4 = slightly pink, 5 = pinkish-grey, 6 = grey brown, and 7 = brown [1]. The "Beef Steak Color Guide" [2] was used as a reference, representing scores 1 through 6. Panelist scores were averaged prior to statistical analysis.

Immediately after panel evaluation, the cut surface of the cooked steak was scanned three times with a portable Minolta colorimeter (specifications previously described). The three observations were averaged prior to statistical analysis.

F. Experimental Design and Statistical Analysis.

Data were analyzed using a completely randomized design, with strip loin as an experimental unit. Raw color, proximate, and pH analyses were performed using a commercially available statistical software package (SAS, SAS Inst. Inc., Cary, NC) as a general linear model. Beta-agonist treatment was included in models for variables pertaining to raw color, composition, and pH. Cooked color analysis was performed using a mixed model with β-AA treatment, postmortem aging (d), and their interaction as fixed effects. Final cooked temperature was included as a covariate. Treatment least squares means were separated with the PDIFF option of SAS at a significance level of $P < 0.05$.

III. RESULTS AND DISCUSSION

1. Raw Proximate composition and pH.

Beta-adrenergic agonist treatment influenced the proximate composition and pH of raw longissimus steaks (Table 1). Steaks from cattle fed ZH or RH had a greater protein content ($P < 0.0001$) than CON steaks. Previous research supports an increase in protein due to ZH supplementation [7]. Though numerically higher in CON steaks, fat content did not differ among treatments ($P = 0.17$). Conversely, Shook et al. [11] observed decreased fat content in ZH fed cattle. Collagen (%) was lower in ZH steaks than CON, though both were similar to RH. Strydom et al. [12] noted a similar collagen response in RH and ZH supplemented steers. Though pH values from ZH steaks were statistically lower than CON, the difference is of little practical significance.

Table 1. Effect of zilpaterol hydrochloride (ZH), ractopamine hydrochloride (RH) or no beta agonist (CON) on the proximate composition (%) and pH of raw longissimus steaks from calf-fed Holstein steers.

	Treatment			*P*- value	SEM
	CON	ZH	RH		
Fat, %	6.41	5.49	5.55	0.17	0.41
Moisture, %	70.44	70.71	70.72	0.31	3.45
Protein, %	22.02[a]	22.45[b]	22.27[b]	<0.0001	0.70
Collagen, %	1.76[b]	1.64[a]	1.70[ab]	0.04	0.31
pH	5.65[b]	5.61[a]	5.62[ab]	0.40	0.01

[ab] Least squares means lacking a common superscript letter differ ($P < 0.05$).

2. Raw Instrumental Color.

The results of previous investigations of the raw lean color of *longissimus* steaks from β-AA treated cattle vary. In the current study (Table 2), steaks from steers supplemented with ZH were less red (lower *a** values; P < 0.01) and less vivid (lower saturation values; $P = 0.01$) than CON or RH steaks. Rogers et al. [10] evaluation of calf-fed Holstein longissimus color suggested ZH had no influence on raw steak color when evaluated using a spectrophotometer with a 2.54-cm aperture (Hunter MiniScan 4500L, Hunter Lab Inc., Reston, WV, USA). On the other hand, *a** and saturation index values from 30 d ZH-fed Bonsmara steers obtained using a one-cm aperture (Minolta CM-2002), coincide with those in the current study [3]. Yancey and Kropf [15] found aperture size influences observed color values. Regardless, the observed differences are likely not recognizable to the human eye.

3. Internal Cooked Color.

With sufficient heating, all myoglobin forms denature to form ferrihemochrome, a grey/brown pigment responsible for cooked meat color [9]. Factors such as stress and high pH can cause improper ferrihemochrome formation and result in residual pink and red in the interior of cooked meat. The presence of pink and red tones in beef products cooked to a “medium-well” degree of doneness (71ºC) has perceived food safety implications. To our knowledge, evaluation of β-AA effects on cooked color has not been performed; however given the use of RH and ZH beef steaks from calf-fed Holsteins in foodservice and retail, an investigation is warranted.

Table 2. Effect of zilpaterol hydrochloride (ZH), ractopamine hydrochloride (RH) or no beta agonist (CON) on the instrumental color values of raw longissimus steaks from calf-fed Holstein steers.

	Treatment			*P*- value	SEM
	CON	ZH	RH		
*L**	43.27	42.83	43.10	0.37	0.22
*a**	24.41[b]	23.71[a]	24.23[b]	<0.01	0.15
*b**	16.84[b]	16.23[a]	16.71[b]	0.03	0.17
Hue angle[1]	34.55	34.25	34.54	0.24	0.14
Saturation Index[2]	29.67[b]	28.79[a]	29.44[b]	0.01	0.21

[ab] Least squares means lacking a common superscript letter differ ($P < 0.05$).

[1] Hue angle = $\tan^{-1} b^*/a^*$

[2] Saturation index = $(a^{*2} + b^{*2})^{1/2}$

Trained color panelists scores indicated ZH and RH steaks were less pink than CON steaks ($P < 0.01$; Table 3). Similarly, ZH steaks tended to be less red (lower *a** values; $P = 0.07$) than either RH or CON steaks. Previous research has indicated beef with higher pH maintains pink/red color due to inadequate myoglobin denaturation [13]. Though not shown, steaks aged for 14 d had higher color scores (4.05; less red; $P < 0.05$) than 21 d steaks (3.92). These results were unexpected and suggest further investigation of the influence of postmortem aging on internal cooked beef color may be warranted.

Table 3. Effect of zilpaterol hydrochloride (ZH), ractopamine hydrochloride (RH) or no beta agonist (CON) on trained color scores and *a** values of cooked 14 or 21 d aged longissimus steaks from calf-fed Holstein steers.

	Treatment			*P*- value	SEM
	CON	ZH	RH		
Trained Color Score[1]	3.87[a]	4.06[b]	4.02[b]	<0.01	0.06
*a** value	31.81[b]	31.22[a]	31.85[b]	0.07	0.05

[1] Trained color score: 3 = pink, 4 = slightly pink.

[ab] Least squares means lacking a common superscript letter differ ($P < 0.05$).

IV. CONCLUSION

Overall, the results of this study support previous research indicating supplementation with RH or ZH alters the proximate composition of raw longissimus steaks. Similarly, raw, mechanically portioned longissimus steaks from ZH supplemented calf-fed Holsteins have a negligible difference in color when compared to CON steaks. The observed differences in cooked color, though small, may warrant investigation of other biochemical traits, such as pigment concentration, which may influence cooked color properties.

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