BRAZILIAN BEEF: A FOCUS ON TENDERNESS AND SARCOMERE LENGTH

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I. INTRODUCTION

With the world's second-largest cattle herd, Brazil assumes a significant role in global meat production, achieving a volume of 10.27 million tons in 2022 [1]. Owing to the country's extensive territorial diversity, this production is influenced by geographic conditions, genetics, production systems, technology, and market demand, leading to variations in meat quality attributes such as color, flavor, and tenderness, crucial for consumer satisfaction. Tenderness is closely associated with ante-mortem factors (e.g., breed, sex, maturity, and feeding) and post-mortem factors (e.g., cooling and electrical stimulation) [2]. These factors, in turn, can impact sarcomere length, fundamental structural unit of the myofibril. Therefore, the present study aims to investigate the quality of Brazilian beef produced in various slaughterhouses across the country, focusing specifically on the relationship between tenderness and sarcomere length.

II. MATERIALS AND METHODS

Samples (n=111; Zebu breeds) of the *Longissimus thoracis* muscle were collected from three slaughterhouses in Brazil (São Paulo, Bahia, and Rondônia). From each facility, five different pens were selected, representing distinct groups of animals (with 5 to 8 samples each; see Table 1). All samples were frozen 48 hours after slaughter. The pH was measured following the protocol outlined by Ramos and Gomide, 2017 [3]. Fat content (%) was determined using near-infrared spectroscopy (FoodScan 2 PRO, Hillerød, Denmark) [4]. Sarcomere length (µm) was measured via laser diffraction, following the methodology described by Battaglia et al., 2020 [5]. Instrumental tenderness (kg; Warner-Bratzler Shear Force) was determined following the guidelines provided by AMSA, 1995 [6]. Analyses were conducted in triplicate, and the data underwent one-way analysis of variance (ANOVA) followed by Tukey's test ($p<0.05$) using Statistica® version 10.0. Additionally, the Pearson Correlation coefficient was calculated for sarcomere length and tenderness.

III. RESULTS AND DISCUSSION

The samples exhibited final pH values ranging from 5.4 to 6.5. However, those with pH ≥ 5.9, indicative of DFD (dark, firm, and dry) characteristics, were excluded from this study to mitigate their impact on tenderness and ensure result consistency. Table 1 illustrates the pen characteristics alongside the results of fat content, sarcomere length, and instrumental tenderness of the samples.

Table 1. Means ± standard error of beef quality parameters from cattle at three Brazilian slaughterhouses.

	Sex	Teeth (Age)	HCW (kg)	EE	Fat (%)	SL (µm)	WBSF (kg)
Slaugterhouse A							
Pen 1, n=6	Intact male	2	342	Yes	2,97 ± 0,10 ^{b}	1,77 ± 0,04 ^{a}	4,87 ± 0,30 ^{a}
Pen 2, n=8	Intact male	2	290	Yes	3,96 ± 0,27 ^{a}	1,73 ± 0,05 ^{a}	6,14 ± 0,49 ^{a}
Pen 3, n=7	Intact male	2	316	Yes	2,78 ± 0,16 ^{b}	1,71 ± 0,03 ^{a}	5,74 ± 0,22 ^{a}
Pen 4; n=6	Intact male	2	342	Yes	3,01 ± 0,20 ^{b}	1,79 ± 0,03 ^{a}	4,90 ± 0,17 ^{a}
Pen 5; n=8	Intact male	2	252	Yes	3,55 ± 0,15 ^{ab}	1,73 ± 0,05 ^{a}	6,01 ± 0,50 ^{a}
Mean	-	-	-	-	3,28 ± 0,11 ^{A}	1,75 ± 0,02 ^{A}	5,56 ± 0,18 ^{C}
Slaugterhouse B							
Pen 6; n=5	Intact male	6	296	No	1,70 ± 0,14 ^{b}	1,63 ± 0,06 ^{ab}	6,98 ± 0,75 ^{ab}
Pen 7; n=8	Intact male	4	314	No	3,24 ± 0,19 ^{ab}	1,66 ± 0,01 ^{ab}	5,59 ± 0,31 ^{ab}
Pen 8; n=8	Female	8	252	No	4,18 ± 0,51 ^{a}	1,57 ± 0,03 ^{b}	6,91 ± 0,63 ^{ab}
Pen 9; n=8	Intact male	4	294	No	4,24 ± 0,69 ^{a}	1,71 ± 0,01 ^{a}	5,10 ± 0,24 b

Pen 10; n=7	Intact male	2	290	No	2,26 ± 0,15 [b]	1,57 ± 0,05 [ab]	7,59 ± 0,71 [a]
Mean	-	-	-	-	3,27 ± 0,25 [A]	1,63 ± 0,02 [B]	6,36 ± 0,28 [B]
Slaugterhouse C							
Pen 11; n=8	Female	8	160	Yes	3,10 ± 2,29 [a]	1,56 ± 0,05 [a]	6,31 ± 0,30 [a]
Pen 12; n=8	Intact male	4	300	Yes	1,71 ± 0,10 [a]	1,48 ± 0,04 [a]	8,03 ± 0,58 [a]
Pen 13; n=7	Female	8	196	Yes	2,39 ± 0,11 [a]	1,58 ± 0,03 [a]	6,24 ± 0,25 [a]
Pen 14; n=8	Female	8	208	Yes	2,95 ± 0,20 [a]	1,45 ± 0,05 [a]	7,38 ± 0,52 [a]
Pen 15; n=7	Female	2	170	Yes	3,00 ± 0,29 [a]	1,53 ± 0,10 [a]	7,67 ± 0,48 [a]
Mean	-	-	-	-	3,09 ± 0,50 [A]	1,52 ± 0,03 [C]	7,13 ± 0,23 [A]

EE: Electrical Stimulation; SL: Sarcomere Length; HCW: Hot Carcass Weight. Different letters within the same column indicate a significant difference between samples as determined by the Tukey test ($p < 0.05$). Lowercase letters denote statistical comparisons among pens, while uppercase letters denote comparisons between slaughterhouses.

The average carcass weight was 269 kg. While fat content varied among some pens, no differences were observed between units. Sarcomere length ranged from 1.21 to 2.05 µm, with notable emphasis on pens from unit A, displaying the highest values. This could be attributed to the larger carcass weight coupled with the application of electrical stimulation, which accelerates the decline in muscle pH, thereby preventing excessive sarcomere shortening [5]. Regarding instrumental tenderness, shear force exhibited a range of 3.6 to 10.4 kg, with only approximately 15% of samples classified as very tender (> 3.0 kg) or tender (4.0 – 4.4 kg). Pens from unit A featured tender meat, possibly owing to the younger age of the animals. These findings highlight a direct correlation between sarcomere length and tenderness, evident by the significant negative correlation coefficient of $r = -0.662$ ($p < 0.05$), where tender meats exhibited longer sarcomeres. This underscores the importance of sarcomere length as a critical predictor of beef tenderness.

IV. CONCLUSION

The variability in the tenderness of Brazilian beef is strongly correlated with sarcomere length. These findings offer valuable insights for the meat industry, emphasizing the significance of incorporating sarcomere length into the animal production and selection process. This approach aims to enhance meat quality and guarantee consumer satisfaction.

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