ENHANCING BEEF QUALITY THROUGH EXTREMELY LOW-FREQUENCY ELECTROMAGNETIC FIELDS: PRELIMINARY RESULTS

Lucas Camargo[1], Rodrigo Lovato[2], Luzo Dantas Jr[2], Murilo Magistri[3], Rodrigo Torres[3], Gregori Rovadoscki[4], Marcelo Coutinho[4], Guilherme Pereira[3], Luis A. Chardulo[3], Welder Baldassini[3*]

[1] São Paulo State University (UNESP), School of Agricultural and Veterinary Sciences, Jaboticabal, Brazil
[2] EFFATHA, Santo André, São Paulo, Brazil
[3] São Paulo State University (UNESP), School of Veterinary Medicine and Animal Science, Botucatu, Brazil
[4] Brazil Beef Quality, Piracicaba, São Paulo, Brazil
*Corresponding author email: w.baldassini@unesp.br

I. INTRODUCTION

The application of extremely low frequency (ELF) electromagnetic fields in meat products is novel in food science. Initial studies have shown improvements in tenderness and cooking loss of fish, particularly carp and rainbow trout [1,2]. However, the application of this technology to beef remains unexplored. Within this context, the present study aims to investigate the effects of ELF on meat quality traits of *Bos indicus* cattle.

II. MATERIALS AND METHODS

Samples of the *Longissimus thoracis* (LT) from 140 Nellore bulls, belonging to contemporary groups and feedlot finished, were used. Seventy LT were allocated for laboratory analyses (study 1), while the remaining 70 were designated for sensory analyses (study 2) of meat quality. Each portion of LT was divided into two steaks of 2.54 cm, vacuum-packed, and frozen (48h *post-mortem*). In both studies, one steak was assigned to the control treatment (CTRL), and the other to ELF. The application of ELF protocol (0 to 100 Hz) was performed using microchips, EFFATHA technology (https://www.effatha.com.br), affixed to the sample packaging. The protocol was applied after sample thawing for 14 hours. The ELF technology targets the amino acid sequences (https://www.uniprot.org/) of the proteins Actin, Myosin, Desmin, Troponin T, Titin, and Nebulin. Subsequently, all samples were aged for seven days (1 to 2° C) and used in the meat quality assays. The steaks from ELF and CTRL treatments remained in separate fridge during these processes.

In study 1, the meat pH and water-holding capacity (WHC) were measured according to procedures described in the literature [3]. Subsequently, the samples were cooked until reaching 71°C to determine the shear force (WBSF) in kilograms, following literature procedures [4,5]. Cooking losses (CL) were calculated as the difference in weight before and after cooking. In study 2, the samples were grilled until reaching 63° C and served to untrained consumers (n = 120), following literature procedures [6]. Grilled steaks were placed in small boxes (https://www.brazilbeefquality.com/) to preserve moisture and kept in ovens at 45°C to standardize the temperature. Each participant received 7 samples: one common to all (*dummy*) and six randomized samples (3 CTRL vs. 3 ELF). Consumers evaluated tenderness (TE), liking of flavor (FL), juiciness (JU), and overall acceptance (OA) on a hedonic scale from 0 to 100 points.

Analysis of variance (ANOVA) was used to test the effect of treatments on meat quality variables. Marginal means were compared using the *emmeans* function in R software (v.4.1.2). In study 2, A mixed generalized linear model was applied considering a binomial distribution using the PROC GLIMMIX procedure (SAS v.9.4). The model included sequence (sample tasting) and treatment (CTRL and ELF) as fixed effects, while consumer as random effects. For all data, significance was detected at the 0.05 level.

III. RESULTS AND DISUSSION

Meat pH was lower ($P < 0.05$) in the ELF treatment compared to CTRL (Figure 1A), which may have occurred due to the exposure of amino acids in the proteins, releasing hydrogen ions and acidifying the cellular environment, as observed in another study with pork [7]. Additionally, there was a 2% increase in WHC ($P < 0.05$) in the steaks from the ELF treatment. These results suggest modifications in the structure of the muscle tissue, affecting protein-water interaction and exposing more hydrophilic groups, which was also observed with pork [8]. Furthermore, objective tenderness improved, with a great reduction of 1.31 kg in WBSF ($P < 0.05$) in the ELF treatment versus CTRL.

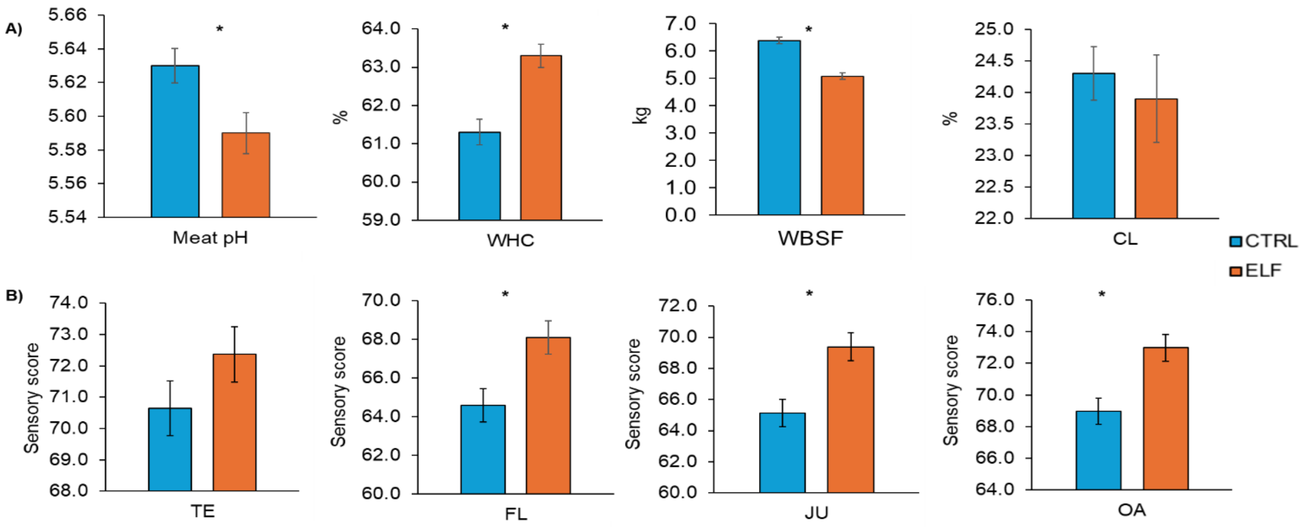

Figure 1. Results of meat quality assays (*Longissimus thoracis* [LT] samples) for control (**CTRL**) versus extremely low-frequency (**ELF** [0 to 100 Hz]) treatment. **A**) Laboratory study (n = 70 LT): WHC = Water-holding capacity; WBSF = Warner-Bratzler shear force; CL = cooking losses. **B**) Sensory study (n = 70 LT) – 120 untrained consumers (sensory score 0 to 100 points): TE = tenderness; FL = liking of flavor; JU = juiciness; OA = overall acceptance. *Significance ($P < 0.05$).

Positive effects ($P < 0.05$) on sensory traits (JU, FL, and OA) were observed (Figure 1B). Consumers gave higher ratings to steaks from ELF treatment compared to CTRL, except for TE variable. Despite its strong correlation with OA, consumers were unable to detect differences in TE alone (individually). Further research is needed to elucidate the underlying biochemical and molecular mechanisms responsible for these improvements and to optimize the application of ELF in beef [9].

IV. CONCLUSION

The use of ELF on Nellore beef reduced pH, increased WHC, and decrease WBSF, improving objective tenderness. Positive effects were also observed after ELF application on sensory traits such as juiciness, liking of flavor, and overall acceptance. These results possibly occurred due to effects on structural proteins of the LT muscle, which can be used to development of innovative strategies for enhancing meat quality of *Bos indicus* animals and meeting consumer preferences in the future.

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