# TREATMENT OF LAMB MEAT WITH HIGH-INTENSITY ULTRASOUND

Fabiana A. Almeida[1*], Arielen A. Quintiliano[1], Laryssa S. Rudeck[1], Gilnara A. N. Saldanha[1], Renata E. F. de Macedo[2], Alda L. G. Monteiro[1]

[1] Federal University of Paraná, Curitiba, Brazil.

[2] Pontifical Catholic University of Paraná, Curitiba, Brazil.

*Corresponding author email: fabianaalmeida@ufpr.br

## I. INTRODUCTION

The evolution of food processes is driven by changes in consumer preferences and the need to produce safe, high-quality food [1]. Ultrasound is an acoustic energy [2], therefore, it is a non-ionizing, non-invasive and non-polluting form of mechanical energy [3]. It is considered an emerging method with great potential to control, improve and accelerate processes without compromising food quality [4; 5].

Studies reported potential uses of high-intensity ultrasound (UAI) in fresh meat, mainly in the Longissimus and Semitendinosus muscles of cattle [6; 7]. There is a notable effect of ultrasound on tissue sensitivity and water dynamics. However, sometimes this effect is positive (softening and water retention), and other times it is negative (hardening and water release) [1]. In this sense, further studies on the subject and using meat cuts from other species are auspicious.

The aim of this study was to evaluate the qualitative characteristics such as pH, color, water holding capacity, cooking loss and tenderness of lamb meat subjected to high-intensity ultrasound treatment.

## II. MATERIALS AND METHODS

The study was approved by the ethics committee for the use of animals in research at the Federal University of Paraná (protocol number 050/2023).

Six loins and six flat were used from the carcass of 120-day-old lambs that were finished in confinement and slaughtered with 38 ± 2 kg of body weight. The lambs came from the same property, were son of the same ram and were subjected to the same nutritional management.

After being removed from the carcass, the cuts were cleaned to remove subcutaneous fat and connective tissue and were vacuum packed and frozen (- 18°C) until analysis was carried out. Subsequently, the cuts thawed in a BOD incubator for 12 hours at 4°C and then subjected to three times in the ultrasound bath: time zero (without ultrasound bath), 5 and 10 minutes. The ultrasound bath (usc-2800a, Unique) used worked at a frequency of 40kHz, temperature of 25°C and a power of 100 W, representing high intensity ultrasound (10–1000 $Wcm^{-2}$) and low frequency (20–100kHz).

After the ultrasound bath, the physical and chemical characteristics of the meat were analyzed: pH, color, water holding capacity (WHC), cooking loss (CL) and shear force (SF). The pH was measured with a peagameter (Testo) and the color was measured on the surface of the samples after being exposed to the environment for 30 minutes. To measure the coordinates L* (lightness), a* (redness) and b* (yellowness), a Minolta CR-400 colorimeter was used.

To obtain the WHC, 0.5 g of meat sample was weighed, placed inside a filter paper and between two acrylic plates and a 10 kg weight was placed on the plates for 5 minutes, after the sample was weighed again and the WHC was given as a percentage of the initial weight. To measure the CL, a 5 x 5 cm sample from each cut was weighed and placed to bake on a grill until the internal temperature reached 70°C. Later, after the samples had cooled and reached a constant weight, they were weighed again and the CL was obtained by difference between the initial weight and the final weight, divided by the initial weight, expressed as a percentage. The cooked samples were cut into cylinders (3 cylinders by sample) and subjected to cutting in the transverse direction of the muscle fibers using the Texture Analyzer device, coupled to the Warner-Bratzler blade, with the values expressed in kgf [8].

The design was completely randomized in a 2 x 3 factorial scheme, two cuts (loin and flat) and three ultrasound times (0, 5 or 10 minutes). The means were compared using the Tukey test at 5% significance and the Minitab 18.0® program was used for statistical analysis.

## III. RESULTS AND DISCUSSION

An interaction between cut and ultrasound time (P= 0.008) was observed only for b*, which was higher in the flat with 11.6 and 12.5 when compared to loin with 9.7 and 9.3 at times 0 and 5 minutes of ultrasound bath, respectively. In 10 minutes of ultrasound the value of b* was 12.3 for loin and 11.9 for flat. The interaction was not observed (P≥ 0.05) for the other parameters evaluated, for this reason, they were evaluated separately within each factor (cut and ultrasound time) (Table 1).
The flat had a lower a* (P= 0.001) when compared to the loin, 7.9 and 8.8, respectively. Studies carried out comparing the color of the Longissimus lumborum and Biceps femoris muscles did not observe a difference in the a* content between them, however the greater amount of connective tissue in the Biceps femoris can change the a* value, although it is lighter.
Even though the value of L* at time 5 did not differ from the others, it appears that the L* content increased with ultrasound time, the value of L* at time 0 was 45.5, at time 5 it was 49.0 and at time 10 was 51.0 (Table 1). According to Stadnik and Dolatowski (2011), ultrasound accelerates total changes in color, limits the formation of oxymyoglobin, and slows down the formation of metmyoglobin. However, effects of ultrasound treatment on the color of fresh meat are not widely reported. Still, as in the present study, some others [9] found changes in the color of fresh meat after ultrasound treatment, becoming less shiny, less red and more yellowish. Other authors [10] also observed an increase in L*, which can be considered a negative effect. According to Sañudo et al. (2000), the variation for lamb meat is from 30.03 to 49.47 for L*, from 8.24 to 23.53 for a* and from 3.38 to 11.10 for b*. This emphasizes the negative effect of ultrasound bath, especially on b* and L* of the lamb meat.

Table 1 – Qualitative traits mean (± standard error) of lamb meat (loin and flat) subjected to high-intensity ultrasound treatment for 0, 5 or 10 minutes.

| Trait | Cut | | | Ultrasound times (minutes) | | | | Pr> F interaction |
|---|---|---|---|---|---|---|---|---|
| | Loin | Flat | Pr>F | 0 | 5 | 10 | Pr>F | |
| pH | 5.7 (±0.03) | 5.7 (±0.05) | 0.491 | 5.6 (±0.07) | 5.7 (±0.04) | 5.7 (±0.06) | 0.936 | 0.380 |
| L* | 47.0 (±0.91) | 50.0 (±1.23) | 0.079 | 45.5b (±0.60) | 49.0ab (±1.24) | 51.0a (±1.06) | 0.012 | 0.501 |
| a* | 8.8 (±0.01) | 7.9 (±0.15) | 0.001 | 8.4 (±0.16) | 8.3 (±0.31) | 8.3 (±0.36) | 0.947 | 0.099 |
| WHC (%) | 63.2 (±2.53) | 62.2 (±1.45) | 0.734 | 62.6 (±2.32) | 58.1 (±1.52) | 66.7 (±1.85) | 0.051 | 0.206 |
| CL (%) | 0.9 (±0.23) | 0.9 (± 0.09) | 0.785 | 0.8 (±0.22) | 1.1 (±0.25) | 0.9 (±0.12) | 0.498 | 0.859 |
| SF (kgf) | 3.7 (±0.34) | 2.7 (±0.14) | 0.021 | 3.2 (±0.33) | 3.5 (±0.53) | 2.8 (±0.36) | 0.524 | 0.886 |

L* (lightness) and a* (redness); WHC= water holding capacity; CL= cooking loss; SF shear force.
For ultrasound time, the means with different letters in the line differ statistically using the Tukey test at 5% probability.

The flat (2.7 kgf) was tender than loin (3.7 kgf) (Table 1), the opposite was expected, as the Biceps femoris muscle, being located in the leg, tends to be harder than Longissimus lumborum. The low age of the animals at slaughter (120-day-old) and finishing in confinement may explain the low SF of flat. However, for both cuts the values of SF are ideal for lamb meat (Table 1). Cut and ultrasound time did not influence (P≥ 0.05) pH, WHC and CL values (Table 1). Lamb meat pH ranged from 5.6 to 5.7, WHC ranged from 58.1 to 66.7 and CL ranged from 0.9 to 1.0. When we analyzed the WHC and CL it was observed that the meat had good water retention and low weight loss during cooking, demonstrating that the *rigor mortis* process occurred correctly, a fact confirmed by the pH values.

## IV. CONCLUSION

The treatment of lamb meat with high-intensity ultrasound negatively affected the color, increasing the lightness and the yellowness. More studies are needed evaluating the use of this technology in sheep meat.

## REFERENCES


1. Alarcon-Rojoa, A. D.; Carrillo-Lopez, L. M.; Reyes-Villagranab, R.; Huerta-Jiménez, M.; Garcia-Galicia, I.A. (2019). Ultrasound and meat quality: A review. Ultrasonics – Sonochemistry 55: 369–382.
2. Hoover, D.G. (2000). Special supplement kinetics of microbial inactivation for alternative food processing technologies (Ultrasound), Journal of Food Science 65: 93–95.
3. Chemat, F.; Zill-e-Huma; Khan, M.K. (2011). Applications of ultrasound in food technology: processing, preservation and extraction, Ultrasound Sonochemistry 18: 813–835.
4. Awad, T.S.; Moharram, H.A.; Shaltout, O.E.; Asker, D.; Youssef, M.M. (2012). Applications of ultrasound in analysis, processing and quality control of food: a review. Food Research International 48: 410–427.
5. Gallego-Juarez, J.A. (2010). High-power ultrasonic processing: recent developments and prospective advances, Physics Procedia 3: 35–47.
6. Caraveo, O.; Alarcon-Rojo, A.D.; Renteria, A.; Santellano, E.; Paniwnyk, L. (2015). Physicochemical and microbiological characteristics of beef treated with highintensity ultrasound and stored at 4 °C. Journal of the Science of Food and Agriculture 95: 2487–2493.
7. Zou, Y.; Zhang, W.; Kang, D.; Zhou, G. (2018). Improvement of tenderness and water holding capacity of spiced beef by the application of ultrasound during cooking, International Journal of Food Science and Technology 53: 828–836.
8. Lyon, C.E.; Lyon, B.G.; Dickens, J.A. (1998). Effects of carcass stimulation, deboning time, and marination on color and texture of broiler breast meat. Journal of Applied Poultry Research 7: 53-60.
9. Stadnik, J., Dolatowski, Z.J. (2011). Influence of sonication on Warner-Bratzler shear force, colour and myoglobin of beef (m. semimembranosus). European Food Research and Technology 233: 553–559.
10. Caraveo, O., Alarcon-Rojo, A.D., Renteria, A., Santellano, E., Paniwnyk, L. (2015). Physicochemical and microbiological characteristics of beef treated with high intensity ultrasound and stored at 4 °C. Journal of the Science of Food and Agriculture. 95: 2487–2493.
11. Sañudo, C., Enser, M.E., Campo, M.M., Nute, G.R., María G., Sierra I., Wood, J.D., (2000). Fatty acid composition and sensory characteristics of lamb carcasses from Britain and Spain. Meat Science, 54: 339-346.