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CONVERSION FROM WARNER-BRATZLER SHEAR FORCE (WBSF) TO SLICE SHEAR FORCE (SSF) TO CLASSIFY PORK LOIN TENDERNESS

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I. INTRODUCTION

Tenderness is a key factor of meat quality and plays a crucial role in consumer perception and overall acceptability. Instrumental methods, such as the Warner–Bratzler Shear Force (WBSF) test, offer reliable alternatives to sensory evaluation, and have been widely applied in pork quality research due to their correlation with sensory attributes [1,2]. Tenderness classification [1,3] based on WBSF values was proposed in agreement with sensory evaluation [1]. Slice Shear Force (SSF) test, originally developed for beef, has emerged as a rapid and effective method for assessing texture, but its application in pork remains limited. The present study is part of the European "mEATquality project", aimed at examining some rearing practices used in European pig husbandry and their effect on intrinsic meat quality. The objective of this work is to investigate the potential of the Slice Shear Force (SSF) method as an effective tool for assessing pork tenderness, by evaluating its correlation with the traditional Warner–Bratzler Shear Force (WBSF) technique and classifying Italian pork loins into distinct tenderness categories.

II. MATERIALS AND METHODS

A total of 300 pork loins (*longissimus thoracis et lumborum*, LTL) were collected from Italian heavy pigs belonging to different breeds and crossbreeds included in the "mEATquality" project to perform distinct experimental trials. The local breeds Mora Romagnola (MR) and Cinta Senese (CS), and the crossbreeds CS×Large White (CS×LW), CSxDuroc (CS×D) and LWxD were used in a "Genetic" trial. Commercial heavy pigs were used for a "Quality of Space" trial (different access to branches and/or shaded areas) and for Space Allowance trials (1 m²/pig, 2 m²/pig and 3 m²/pig indoor, and 1.3 +1 m²/pig, 2.6 +2 m²/pig 3.9 +3 m²/pig indoor + outdoor). Trials of Space Allowance and Quality of Space were replicated in summer and winter, and each experimental group included at least 10 animals. For each animal, four chops (3.5 cm thick) were collected from the LTL at 72 h postmortem between the 9th and 13th rib, vacuum-packed and stored at < –20 °C until analysis. SSF and WBSF were analyzed with Instron 5545 equipped with a 500 N load cell, by following AMSA (2016) guidelines [4] and the peak maximum shear force as Newton (N) was recorded for both methods. Prior to analysis, samples were thawed at 4 °C for 24 hours. In SSF analysis, two chops for each LTL were cooked on a preheated electric grill (180–200 °C) until an internal temperature of 72 °C. Immediately after cooking, two slices (5.0 cm x 1.0 cm) were obtained using the SSF Kit (Slice Shear Force Kit, Gessford Machine Shop, Hastings, NE), following a standard procedure to ensure consistency in sample size and fiber orientation. Slices were sheared perpendicularly to the muscle fibers using a flat blunt-end blade (1.1684 mm thick, beveled to a half-round) and a crosshead speed of 500 mm/min. WBSF analysis was performed on a subset of 100 loin chops (two samples from LTL of 50 pigs). Meat samples were cooked in a water bath at 76 °C until 72 °C inner temperature, and cooled at 2–4 °C for 24 hours. From each chop, at least six cylindrical cores (1.27 cm diameter) parallel to the muscle fibers were sheared perpendicularly using a Warner–Bratzler blade (V-shape, 1 mm thick, 60° angle) and a crosshead speed of 200 mm/min.

III. RESULTS AND DISCUSSION

SSF values ranged from 55.7 to 292.9 N (mean = 97.5 ± 33.5 N), while WBSF ones ranged from 21.0 to 89.0 N (mean = 42.0 ± 16.7 N). The broad variability observed with both methods reflects the heterogeneity of the samples, in agreement with similar studies [1]. Measurements were taken from the cranial-central LTL, typically more tender than the caudal part; results may differ according to anatomical positions along LTL [5]. The regression equation (Figure 1) was applied to convert each other WBSF and SSF values. Next, according to tenderness WBSF thresholds proposed by Destefanis et al. [1], four instrumental tenderness classes were defined after conversion into SSF values, to classify 300 pork loins (Figure 2): "very tender" (SSF < 98.66), "tender" (98.66 < SSF ≤ 130.09), "intermediate" (130.09 < SSF ≤ 161.84), and "tough" (SSF > 161.84). Among the 300 pork loins, 65% were classified as very tender, 24% as tender, 8% as intermediate, and

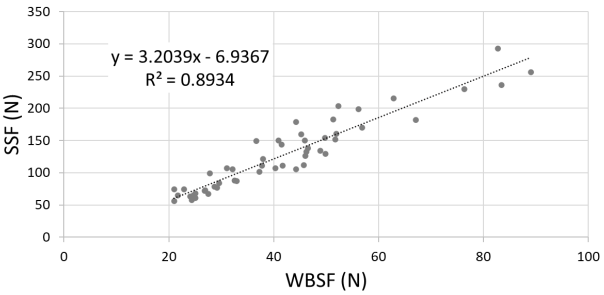

Figure 1. Scatterplot with the correlation between Warner–Bratzler Shear Force (WBSF) and Slice Shear Force (SSF) peak force values in pork loin samples (n = 50).

4% as tough. Loins from CS, MR, CSxLW and CSxD were mainly classified as tender and very tender. In the Quality of Space trials, season influence appeared to outweigh welfare enrichment (animals slaughtered in winter compared to summer showed a higher incidence of intermediate and tough samples). In the Space Allowance trials, the season influence was confirmed: loins provided in summer were predominantly classified as very tender, regardless of space allowance conditions. Conversely, in winter, tenderness was affected by space availability: pigs housed with lower space allowance produced intermediate or tough meat in about 50% of cases: as space allowance increased, a positive shift in tenderness was observed. The Indoor + Outdoor trial exhibited the highest incidence of tender and very tender meat with a percentage ranging from 90% to 100% in the case of animals slaughtered in summer.

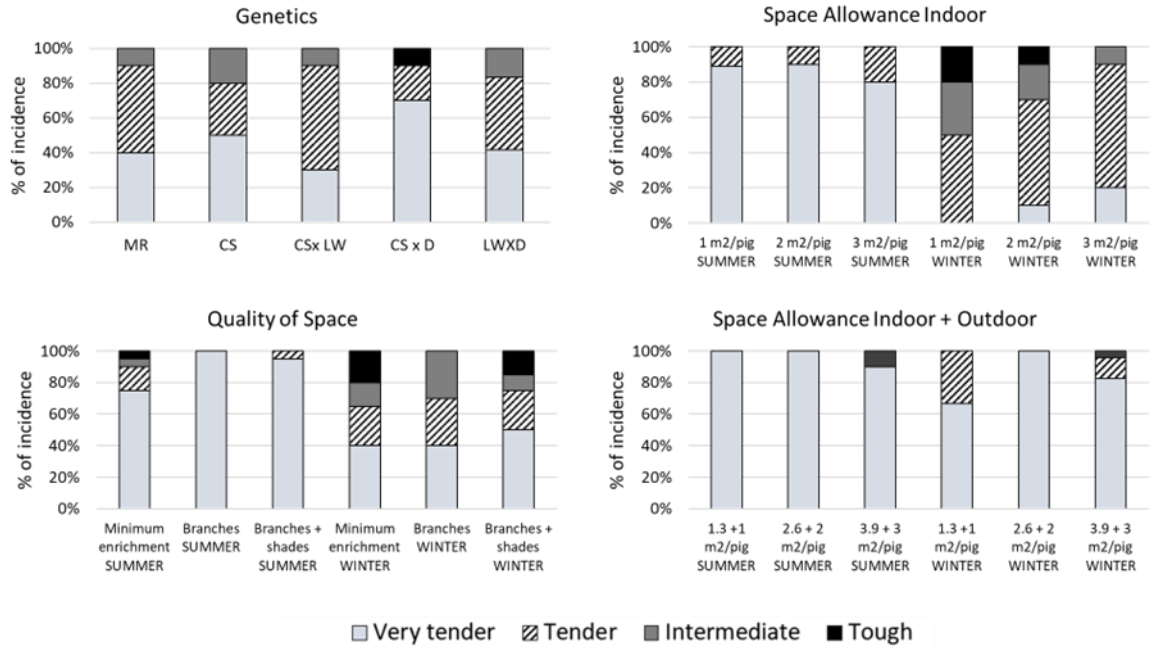

Figure 2. Distribution of tenderness classes (%) across different experimental trials. In the "Genetics" trial MR = Mora Romagnola, CS = Cinta Senese, CS×LW = Cinta Senese × Large White, CS×LW = Cinta Senese × Duroc, LW×D = Large White × Duroc. Commercial heavy pigs were used for Quality of Space and Space Allowance trials.

IV. CONCLUSION

This study shows the suitability of the Slice Shear Force (SSF) method as a reliable tool for assessing pork tenderness, showing a strong correlation with the traditional Warner–Bratzler method. The classification of loins into tenderness categories highlights the variability of pork tenderness due to genetics, space allowance, and slaughtering season. In these trials, space allowance and outdoor access were positively associated with tenderness, especially in animals slaughtered in summer. These findings support the use of SSF in large-scale meat quality assessments and offer insights into how farming practices affect intrinsic meat quality.

Ethical statement

This study did not require ethical approval, as it was conducted under standard farming conditions. Animals were handled according to EU and national legislation, ensuring animal welfare throughout the production cycle.

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V. REFERENCES

1. Destefanis, G., Brugiapaglia, A., Barge, M. T., & Dal Molin, E. (2008). Relationship between beef consumer tenderness perception and Warner–Bratzler shear force. Meat Science, 78(3), 153–156.
2. Miller, M. F., Carr, M. A., Ramsey, C. B., Crockett, K. L., & Hoover, L. C. (2001). Consumer thresholds for establishing the value of beef tenderness. Journal of Animal Science, 79(12), 3062–3068.
3. Zduńczyk, W., Tkacz, K., Pietrzak-Fiećko, R., Bottari, B., & Modzelewska-Kapituła, M. (2023). Pork as a source of nutrients in a human diet – Comparison of meat obtained from conventional and organic systems offered in the Polish market. Meat Science, 37, 10.
4. AMSA (American Meat Science Association). (2016). Research guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of meat (2nd ed.). American Meat Science Association.
5. Janz, J. A. M., Aalhus, J. L., Dugan, M. E. R., & Price, M. A. (2005). A mapping method for the description of Warner–Bratzler shear force gradients in beef Longissimus thoracis et lumborum and Semitendinosus. Meat Science, 72 (79-90).