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MICROBIAL, TECHNOLOGICAL, AND SENSORY CHARACTERIZATION OF DRY- AND WET-AGED *ALBERA* BEEF

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I. INTRODUCTION

Amidst changing consumer demands in Europe [1], local beef breeds present an opportunity for sustainable and high-quality meat production. Among these is the *Albera*, an endangered breed [2] from the Albera Massif, between France and Spain, and under a recovery program since 2010. While recognized for their valuable contribution to environmental maintenance, the potential of *Albera* cattle for premium beef production remains largely underexplored. Along to on-farm factors, such as diet and production systems, post-mortem ageing, particularly dry and wet methods, significantly influences beef sensory quality through physicochemical and microbiological changes [3–5]. Despite general knowledge of quality changes and microbial dynamics during ageing [8–10], specific data on *Albera* beef are scarce. This study aims to assess the technological and sensory characteristics and microbial communities of *Albera* beef aged under dry and wet conditions for 4 and 8 weeks, to optimize its quality and support the valorization of this unique and endangered breed.

II. MATERIALS AND METHODS

Twenty whole loins from the Albera breed, 10 purebred and 10 crossbred animals, produced with two different production systems, were aged under controlled environmental chambers maintained at 1.5 ± 0.6 °C and 86.3 ± 8.5% relative humidity for 4 and 8 weeks. Throughout the ageing period, and at the initial time point, a range of technological and sensory characteristics were evaluated. Analyses included pH determination, color (CIELAB), texture via Warner-Bratzler shear force, water activity (a_w). Sensory attributes were assessed following established methodologies.

Traditional plate count techniques were employed to quantify populations of Enterobacteriaceae, lactic acid bacteria (LAB), Gram-positive catalase-positive cocci, *Staphylococcus aureus*, *Pseudomonas* spp., sulfite-reducing clostridia, the total viable count (TVC) and yeasts and molds. The presence of specific foodborne pathogens, i.e. *Salmonella* spp., *Listeria monocytogenes*, and Shiga toxin-producing *Escherichia coli* (STEC), was investigated in 25 g-samples using real-time PCR assays after enrichment. To gain deeper insights into the bacterial community structure, high-throughput sequencing of the 16S rRNA gene (V3–V4 region) was performed on a subset of samples (n=34). The resulting sequence data underwent processing using the QIIME2 platform and were subsequently analyzed using compositional data analysis following a centered log-ratio (CLR) transformation. Statistical analyses, including assessments of alpha and beta diversity as well as differential abundance, were conducted in R. The significance of differences was determined using PERMANOVA, Kruskal-Wallis, Dunn's post-hoc test, and Mann-Whitney U tests, with a statistical significance threshold set at $p < 0.05$.

III. RESULTS AND DISCUSSION

Aging significantly impacted both the technological and sensory properties of Albera beef, with the production system (purebred vs. crossbred) and aging method (dry vs. wet) playing crucial roles. Technologically, pH increased during aging, particularly with dry-aging. Crossbred animals developed more tender meat and color parameters (luminosity and yellowness) increased in this group during aging, unlike in purebred. Sensory analysis revealed that odor intensity, and "aged meat" aroma intensified with aging, more so in wet-aged beef. Texturally, all attributes changed significantly with aging, with dry-aged meat becoming less juicy, and chewable. Crossbred meat exhibited less drastic textural changes. Flavor intensity increased with aging, while acidic notes decreased. Purebred meat was characterized by lower "aged" flavor intensity, more liver flavor, higher acidity, and greater astringency, achieving acceptable tenderness around 4 weeks of aging.

Dry-aging resulted in significantly higher TVC, yeasts and molds, and *Pseudomonas* counts compared to wet-aging. Lactic acid bacteria proliferated in vacuum-packaged wet-aged meat up to 8 weeks. While *Salmonella spp.* and STEC were not detected, *Listeria monocytogenes* was detected in a subset of samples across all conditions. These

findings underscore the influence of aging methods on the microbial ecology of beef and highlight the importance of monitoring for potential pathogens.
Microbiota analysis revealed distinct taxonomic profiles and diversity patterns influenced by the aging method. Dry-aged samples exhibited lower alpha diversity and were dominated by *Pseudomonas fragi*, *Pseudomonas* sp., and *Brochothrix thermosphacta*. Wet-aged samples showed higher alpha diversity and a more balanced community, enriched in lactic acid bacteria like *Lactilactobacillus sakei* and *Leuconostoc gelidum*. Beta diversity analysis clearly separated the microbial communities of dry-aged and wet-aged samples.

IV. CONCLUSION

Recognizing the endangered status of the Albera breed, this research demonstrates the value of meat aging as a tool to significantly improve its sensory attributes, thereby offering a pathway to enhance consumer acceptance and support breed conservation. The study also emphasizes the distinct impacts of production systems (purebred vs. crossbred) and diet on the meat's technological and sensory characteristics, notably flavor and texture. Additionally, it confirms the impact of the aging method, apart from technological and sensory attributes, also on the meat microbiota, while the detection of foodborne pathogens highlights the importance of controlling the process to guarantee safe products. Further research can be conducted to better understand the relationship between the sensory profile food print and chemical composition regarding volatile compounds, fatty acid profiles, etc.

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