71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

IMPACT OF PH ON BEEF QUALITY: REFINING CLASSIFICATION OF DARK CUTTING BEEF

Pérez-Prida J.M.[1*], Álvarez-Iglesias N.[1], González-Blanco L.[2], Alegre D.[2], Sentandreu E.[2], Sentandreu M.A.[2], Jiménez Y.[3], Soto-Tello J.[3], García-Torres S.[3], Mesías F.J.[4], Prado-Marrón N.[5], Sierra V.[1], Oliván M.[1]

[1] Area of Livestock Production Systems, Regional Service for Agri-Food Research and Development (SERIDA), 33300 Villaviciosa, Spain

[2] Institute of Agrochemistry and Food Technology (IATA-CSIC), 46980, Valencia, Spain

[3] Center for Scientific and Technological Research of Extremadura (CICYTEX-La Orden), 06187 Badajoz, Spain.

[4]. Department Economics. University of Extremadura, Ctra. Cáceres, s/n, 06071, Badajoz, Spain

[5]ASINCAR, Polígono de la Barreda, Parcela 1, 33180 Noreña, Spain.

*Corresponding author email: josemaria.perezprida@asturias.org

I. INTRODUCTION

In beef, quality defects that lead to consumer rejection and, consequently, economic losses and food waste, are often associated with color alterations, such as dark-cutting (DC) or DFD beef (*dark, firm, and dry*). A high pH value at 24 hours *post-mortem* (pH_{24}) is considered a reliable indicator of this defect; however, there is no universal pH threshold for classifying DFD beef [1]. This study aims to monitor the evolution of key meat quality traits (color, water-holding capacity, microbial contamination and texture) during *post-mortem* aging (48 hours to 14 days) in beef from different Spanish regions (Asturias, Valencia and Extremadura) comparing normal-quality beef (CONTROL, $5.5<pH_{24}<5.7$), with defective beef divided as dark-cutting beef (DC, with $5.8<pH_{24}<6.2$) and extreme DFD ($pH_{24}>6.2$).

II. MATERIALS AND METHODS

The pH_{24} of the *Longissimus Thoracis et Lumborum* (LTL) muscle was monitored in over 700 yearling bull carcasses from different beef breeds, slaughtered in commercial abattoirs across Spain (Asturias, Valencia and Extremadura). A total of 24 extreme DFD ($pH_{24}>6.2$) and 22 DC ($5.8< pH_{24} <6.2$) cases were identified. Additionally, 40 carcasses with similar characteristics (weight, sex, age, origin) but normal pH_{24} (5.4–5.7) were selected as CONTROL samples. At 48 hours *post-mortem (pm)* a portion of the LTL muscle (10^{th} to 13^{th} rib) was collected and cut into 2.5 cm steaks for analysis of color (L*, a*, b*, C*, Hue^o), water-holding capacity (WHC, measured as centrifugal drip), microbiological load (Total Viable counts (TVC), *Enterobacteriaceae* (Ent) and Lactic Acid Bacteria (LAB)). In addition, tenderness (Warner-Bratzler shear force (WBSF) test) was assessed along *pm* maturation as described by González-Blanco [2]. The effects of pH_{24} sample type (CONTROL *vs.* DFD *vs.* DC), *pm* time (48h *vs*. 3d *vs*. 7d *vs* 14 d), and their interaction, on beef quality traits were analyzed by a general linear model with Tukey post-hoc test (Games Howell when variances were not homogeneus) in SPSS v.22.

III. RESULTS AND DISCUSSION

The pH_{24} sample type significantly influenced color parameters (Table 1), showing a clear gradient of CON>DC>DFD for L*, a* and b*, with DFD samples exhibiting the lowest values (P<0.001). The only exception was Chroma (C*), where CON and DC samples showed similar values, being significantly higher than those of DFD beef. There was a significant increase of a* (P<0.001) and b* (P<0.01) during the *pm* maturation period.

Table 1 – The effect of pH_{24} sample type (CONTROL, DC, and DFD*), post-mortem* time (48h, 3, 7 and 14 days), and their interaction on drip loss and color parameters (mean ± SEM).

	pH_{24} sample type (T)				Post-mortem time (t)					*P-value*		
	CONTROL ($5.4<pH_{24}<5.7$)	DC ($5.8<pH_{24}<6.2$)	DFD (pH24>6.2)	SEM	48h	3d	7d	14d	SEM	T	t	T x t
L*	36.53c	32.99b	30.82a	0.31	33.66	33.63	33.65	32.86	0.37	0.000	0.324	0.091
a*	11.76c	9.35b	7.72a	0.19	9.08a	9.11a	9.82b	10.43b	0.23	0.000	0.000	0.529
b*	9.317c	5.846b	4.808a	0.25	6.43ab	6.02a	6.76ab	7.41b	0.29	0.000	0.006	0.530
C*	46.276b	47.619b	16.668a	4.12	33.15	32.97	37.14	44.16	4.81	0.000	0.307	0.999
Hue^o	28.23a	17.81b	27.85a	1.94	25.31	24.57	24.11	25.47	2.27	0.000	0.0972	0.998
Drip (%)	30.21b	24.36a	25.14a	0.69	28.85c	27.52bc	25.57ab	24.33a	0.81	0.000	0.000	0.173

The centrifugal Drip loss varied significantly between CONTROL and defective samples (DC and DFD, P<0.001), with DC and DFD showing lower drip loss, then retaining more water. Additionally, drip loss progressively decreased during *pm* maturation. These results agree with previous studies describing both DFD and DC beef as having a darker color and higher WHC [3].
Furthermore, DFD beef showed a much faster spoilage rate (Figure 1), which exceeded the legal limits for TVC (6.69 log CFU/g) and ENT (4 log CFU/g) [4] by day 14 *pm.* These findings support previous research indicating that a pH_{24}>6 creates optimal conditions for rapid microbial growth, leading to unpleasant odors, accelerated spoilage, and with significant reduction in shelf life [5].

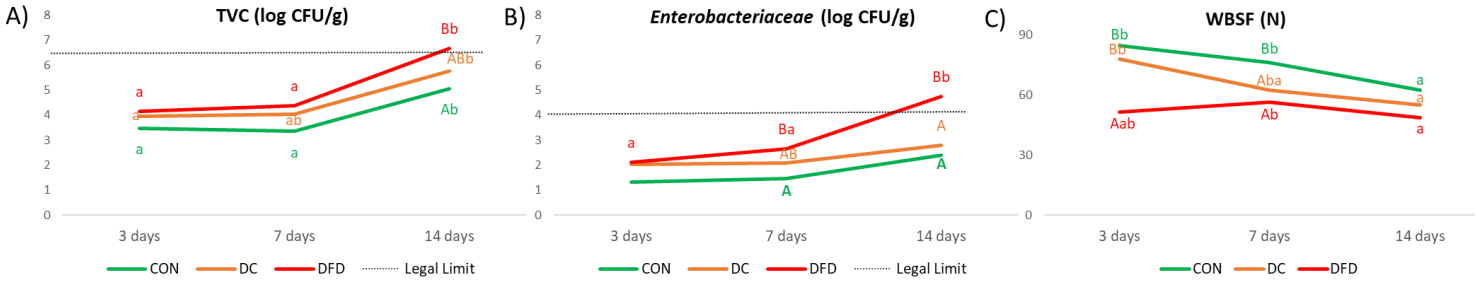


Figure 1. *Post-mortem* evolution of A) total viable counts (TVC, logCFU/g) B) *Enterobacteriaceae* (logCFU/g) C) Warner-Bratzler Shear Force values (N, newtons). Different capital letters indicate significant differences between pH_{24} sample types and different minor letters between *post-mortem* ageing times.

Regarding meat tenderness, significant differences were found between CON, DC, and DFD beef types. While CON and DC beef underwent a gradual reduction of meat toughness over time, the tenderization pattern was stopped in DFD meat, that showed the lowest WBSF values throughout the *pm* maturation period.

IV. CONCLUSION

Beef with high ultimate pH may be classified into two categories, dark-cutting “DC” (5.8<pH_{24}<6.2) and DFD (pH_{24}>6.2), that show different degrees of meat quality alteration. DFD samples have the darkest color, the highest WHC, the fastest spoilage rate and a consistently abnormal low texture, unlike DC and CON samples, which follow a normal *pm* tenderization pattern. The differences observed between DC and DFD samples emphasize the need for a more detailed classification based on pH_{24} ranges, which would help minimize economic losses and reduce food waste.

ACKNOWLEDGEMENTS

This work was funded by MICIN/AEI/10.13039/501100011033 and ERDF ‘A way making Europe’ under project PID2021-123933OR. L.G-B. (PRE2019-091053), N.A-I. (PRE2022-102928) and J.M.P-P. (PRE2022-104089) grants funded by MICIN/AEI/10.13039/501100011033 and ESF “investing in your future”. Authors are members of Consortium cROS (IDI/2024/000719) and Consortium NySA-SERIDA (IDI/2024/000764) financed by Asturias Government, SEKUENS and ERDF.

REFERENCES

1. González-Blanco, L.; Olivan, M.; Diñeiro, Y.; Bravo, S.B.; Sierra, V.; Gagaoua, M. (2024) Sequential window acquisition of all theoretical mass spectra (SWATH-MS) as an emerging proteomics approach for the discovery of dark-cutting beef biomarkers. Meat Science 217:109618.
2. González-Blanco, L.; Sierra, V.; Diñeiro, Y.; Coto-Montes, A.; Olivan, M. (2023) Role of the endoplasmic reticulum in the search for early biomarkers of meat quality. Meat Science 203:109224.
3. Ijaz, M.; Li, X.; Zhang, D.; Hussain, Z.; Ren, C.; Bai, Y.; Zheng, X. (2020). Association between meat color of DFD beef and other quality attributes. Meat Science 161:107954.
4. Shange, N.; Makasi, T.N.; Gouws, P.A.; Hoffman, L.C. (2018) The influence of normal and high ultimate muscle pH on the microbiology and colour stability of previously frozen black wildebeest (Connochaetes gnou) meat. Meat Science 135: 14-19.
5. Gill, A.O., Gill, C.O. (2005). Preservative packaging for fresh meats, poultry, and fin fish. In Han J.H.Innovations in food packaging (pp. 204–226). Academic Press.