

SUPPLEMENTARY MATERIAL

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**Microbiological safety of dry-aged meat:
a critical review of data gaps and research needs to define process hygiene and safety
criteria**

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Supplementary Table 1. Data on total bacteria count, *Enterobacteriaceae* and coliforms including *Escherichia coli* retrieved from the literature and dry-aging duration in days, relative humidity in %, air ventilation in m/sec, meat type, time points, type of sampling, pH, and water activity.

Ref.	Days	RH (%)	Vent. (m/s)	T (°C)	Meat type	Time-point	Type of sampling	pH	a _w	TBC	<i>Enterobacteriaceae</i>	Coliforms/ <i>E. coli</i>
Smaldone <i>et al.</i> (2019)	290	68-70	NA	0	Sirloin steak muscle	T0 Tend	Steaks	T0 5.7 ¥ Tend 5.98 ¥	T0 0.965 ¥ Tend 0.955 ¥	T0 6.82 Log ₁₀ CFU/g Tend 6.13 Log ₁₀ CFU/g	T0 2.58 Log ₁₀ CFU/g Tend 2.08 Log ₁₀ CFU/g	NA
Lee <i>et al.</i> (2017)	28	85	5±3	1±1	Sirloin	T0 Tend	Surface (crust)	T0 5.48	NA	T0 5.60 Log ₁₀ CFU/g Tend 6.58 CFU/g	NA	< 10 CFU/g
	28	75	NA	2±1						T0 5.60 Log ₁₀ CFU/g Tend 7.01 CFU/g	NA	< 10 CFU/g
Bernardo <i>et al.</i> (2021)	21	65	2.5	2	Loin	T0 Tend	Internal (I)	T0 5.39 Tend 5.51	T0 0.993 Tend 1 0.9887 S 0.9730	T0 1.6 Log ₁₀ CFU/g Tend 2.65 Log ₁₀ CFU/g	T0 < 1.1 Log ₁₀ CFU/g Tend < 1 Log ₁₀ CFU/g	NA
							Surface (S)			T0 1.6 Log ₁₀ CFU/g Tend 4.12 Log ₁₀ CFU/g	T0 < 1.1 Log ₁₀ CFU/g Tend < 1 Log ₁₀ CFU/g	NA
	21	85	2.5	2			I			T0 1.6 Log ₁₀ CFU/g Tend 5.26 Log ₁₀ CFU/g	T0 < 1.1 Log ₁₀ CFU/g Tend 3.42 Log ₁₀ CFU/g	NA
							S			T0 1.6 Log ₁₀ CFU/g Tend 9.47 Log ₁₀ CFU/g	T0 < 1.1 Log ₁₀ CFU/g Tend 7.71 Log ₁₀ CFU/g	NA
Hulánková <i>et al.</i> (2018)	12-36	85	0.5±0.2	1±1	Quarter (loin without bone)	T0 Tend	S	NA	T0 2.59 Log ₁₀ CFU/cm ² Tend > 5 Log ₁₀ CFU/cm ²	T0 < 10 CFU/g Tend < 10 CFU/g	NA	
							I		T0 2.17 Log ₁₀ CFU/g Tend > 4 Log ₁₀ CFU/g		NA	
Li <i>et al.</i> (2014)	21	75	NA	5.1	<i>Longissimus thoracis et lumborum</i> section	T1(8d) T2(19d)	Subcutaneous fat (F) and lean surface (M)	T1 5.58 T2 5.63	NA	T1 F 5.22 Log ₁₀ CFU/cm ² M 6.39 Log ₁₀ CFU/cm ² T2 F 6.91 Log ₁₀ CFU/cm ² M 8.75 Log ₁₀ CFU/cm ²	T1 F 0.78 Log ₁₀ CFU/cm ² M 2.09 Log ₁₀ CFU/cm ² T2 F 2.10 Log ₁₀ CFU/cm ² M 5.35 Log ₁₀ CFU/cm ²	NA
Di Paolo <i>et al.</i> (2023)	60	78±10	0.5	1±1	Ribeye steaks	T0 T1(15d) T2(30d) Tend	Steaks	T0 5.70 T1 5.64 T2 5.66 Tend 5.72	T0 0.982 T1 0.973 T2 0.980 Tend 0.976	T0 4.10 Log ₁₀ CFU/g T1 5.45 Log ₁₀ CFU/g T2 5.31 Log ₁₀ CFU/g Tend 5.38 Log ₁₀ CFU/g	T0 1.78 Log ₁₀ CFU/g T1 2.28 Log ₁₀ CFU/g T2 1.73 Log ₁₀ CFU/g Tend 1.92 Log ₁₀ CFU/g	T0 3.08 Log ₁₀ CFU/g T1 3.52 Log ₁₀ CFU/g T2 1.75 Log ₁₀ CFU/g Tend 3.93 Log ₁₀ CFU/g

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DeGeer <i>et al.</i> (2009)	21-28	50	NA	2.2	Loin	T0 Tend	F and M	Shell loin (SH) 5.51 Strip loin (ST) 5.49 21d 5.49 28d 5.49	NA	T0 SH 2.89 Log ₁₀ CFU/cm ² SL 3.16 Log ₁₀ CFU/cm ² Tend SH 3.51 Log ₁₀ CFU/cm ² ST 2.89 Log ₁₀ CFU/cm ²	NA	T0 SH < 10 CFU/cm ² ST 0.88 Log ₁₀ CFU/cm ² Tend SH < 10 CFU/cm ² ST -0.39 Log ₁₀ CFU/cm ²
Ahntstörn <i>et al.</i> (2006)	14-21	87± 2.6	NA	2.6± 0.4	Strip loin	T0 Tend	F and M	T0 5.4±0.1 Tend 14d 5.5 21d 5.7	NA	T0 < 2.5 Log ₁₀ CFU/cm ² Tend F 14d 4.3 Log ₁₀ CFU/cm ² F 21d 4.7 Log ₁₀ CFU/cm ² M 14d 5.1 Log ₁₀ CFU/cm ² M 21d 4.3 Log ₁₀ CFU/cm ²	NA	NA
Khazzar <i>et al.</i> (2023)	30	75	0.5	3± 0.5	Boneless strip loin	T0 T1(7d) Tend	Meat	T0 5.63 T1 5.54 Tend 5.60	T1 0.99 Tend 0.98	T1 2.5 Log ₁₀ CFU/g Tend 4.5 Log ₁₀ CFU/g	T1 1 Log ₁₀ CFU/g Tend 1.9 Log ₁₀ CFU/g	NA
Mikami <i>et al.</i> (2021)	35	90	1.8- 2.5	2.9	Rump	Tend	Crust (C) and inner part (I)	5.62	NA	C 4.64 Log ₁₀ CFU/cm ² I 5.32 Log ₁₀ CFU/cm ²	NA	C 3.10 Log ₁₀ CFU/cm ² I 3.64 Log ₁₀ CFU/cm ²
Ryu <i>et al.</i> (2018)	60	80-90	NA	1-4	<i>Longissimus thoracis</i> section (LT) and <i>Biceps femoris</i> (BS) section	T0 T1(25d) T2(40d) T3(50d) Tend	Surface	NA	NA	LT T0 ~ 2.5 CFU/g ¥ Tend ~ 5.0 CFU/g ¥ BS T0 ~ 2.0 CFU/g ¥ Tend ~ 5.5 CFU/g ¥	NA	< 10 CFU/g
Cambell <i>et al.</i> (2001)	21	75	NA	2	Short loin and strip loin	T0 T1(7d) T2(14d) Tend	Surface	NA	NA	T0 1.4 Log ₁₀ T1 3.3 Log ₁₀ T2 3.9 Log ₁₀ Tend 3.3 Log ₁₀	NA	NA
Gowda <i>et al.</i> (2022)	21-70	40-75	NA	-1 to +3	Bone-in, mainly loins	T0 Tend	S and I	Tend (steaks) 5.73	Tend (steaks) 0.98-0.99	Loin 4.1 Log ₁₀ CFU/cm ² § Steak 3.4 Log ₁₀ CFU/cm ² §	T0 < 6.4 Log ₁₀ CFU/cm ² Tend < 7.4 Log ₁₀ CFU/cm ²	NA

Lancaster <i>et al.</i> (2022)	45	64.87 - 92.21	0.56 - 2.03	0.74 - 5.26	Bone-in strip loin	Tend	Surface (swab)	5.61-5.73	0.98-0.99	0.18-4.00 CFU/cm ²	NA	0.59-4 CFU/cm ²
Van Damme <i>et al.</i> (2022)	42	75-85	NA	2-6	Loin	T0 Tend	F and M	T0 5.50 Tend 5.77	NA	T0 F 2.9 Log ₁₀ CFU/cm ² M 2.3 Log ₁₀ CFU/cm ² Tend F 5.1 Log ₁₀ CFU/cm ² M 2.5 Log ₁₀ CFU/cm ²	T0 F < 0 Log ₁₀ CFU/cm ² M < 0 Log ₁₀ CFU/cm ² Tend F 1.6 Log ₁₀ CFU/cm ² M 0.4 Log ₁₀ CFU/cm ²	NA
Berger <i>et al.</i> (2018)	28	78	< 0.2	2	Bone-in loin	T0 T1(21d) Tend	Steak (internal)	T0 5.89 Tend 5.79	NA	T1 4.046 Log ₁₀ CFU/ml	NA	NA
Shi <i>et al.</i> (2020)	14	85	1.5	2	<i>Longissimus thoracis</i> muscle	T0 T1(7d) Tend	Inner part	T0 5.41 T1 5.58 Tend 5.61	NA	T0 4.62 Log ₁₀ CFU/g T1 7.21 Log ₁₀ CFU/g Tend 7.53 Log ₁₀ CFU/g	NA	NA

*before trimming; **after trimming; TBC, total bacterial count; RH, relative humidity; Vent, air ventilation; a_w, water activity; ¥, data have been retrieved from the figures; §, data have been retrieved from the supplementary material.

Supplementary Table 2. Data on psychrotrophic bacteria, lactic acid bacteria, and *Pseudomonas* spp. retrieved from the literature and dry-aging duration in days, relative humidity in %, air ventilation in m/sec, meat type, time points, type of sampling, pH, and water activity.

Ref.	Days	RH (%)	Vent. (m/s)	T (°C)	Meat type	Time-point	Type of sampling	pH	a _w	Psychrotrophic bacteria	Lactic acid bacteria	<i>Pseudomonas</i> spp.
Hulánková <i>et al.</i> (2018)	12-36	85	0.5±0.2	1±1	Quarter (loin without bone)	T0 Tend	Surface (S) Internal (I)	T0 5.68-5.53-5.60-5.67 Tend 5.68-5.60-5.62-5.68	NA	T0 2.47 Log ₁₀ CFU/cm ² Tend ~5 Log ₁₀ CFU/cm ² ¥ T0 2.13 Log ₁₀ CFU/g Tend ~4.5 Log ₁₀ CFU/g ¥	T0 1.04 Log ₁₀ CFU/cm ² Tend ~1.5 Log ₁₀ CFU/cm ² ¥ T0 0.85 Log ₁₀ CFU/g Tend ~1.5 Log ₁₀ CFU/g ¥	T0 < LOD Tend < LOD
Di Paolo <i>et al.</i> (2023)	60	78±10	0.5	1±1	Ribeye steaks	T0 T1(15d) T2(30d) Tend	Steaks	T0 5.70 T1 5.64 T2 5.66 Tend 5.72	T0 0.982 T1 0.973 T2 0.980 Tend 0.976	T0 2.27 Log ₁₀ CFU/g T1 4.33 Log ₁₀ CFU/g T2 3.29 Log ₁₀ CFU/g Tend 3.58 Log ₁₀ CFU/g	T0 2.41 Log ₁₀ CFU/g T1 3.00 Log ₁₀ CFU/g T2 2.94 Log ₁₀ CFU/g Tend 3.23 Log ₁₀ CFU/g	T0 2.06 Log ₁₀ CFU/g T1 3.89 Log ₁₀ CFU/g T2 2.65 Log ₁₀ CFU/g Tend 3.18 Log ₁₀ CFU/g
Cambell <i>et al.</i> (2001)	21	75	NA	2	Short loin and strip loin	T0 T1(7d) T2(14d) Tend	Surface	NA	NA	NA	T0 1.4 Log ₁₀ T1 1.4 Log ₁₀ T2 1.5 Log ₁₀ Tend 2.0 Log ₁₀	T0 2.8 Log ₁₀ T1 3.5 Log ₁₀ T2 5.3 Log ₁₀ Tend 3.3 Log ₁₀
Ryu <i>et al.</i> (2018)	60	80-90	NA	1-4	<i>Longissimus thoracis</i> section (LT) and <i>Biceps femoris</i> (BS) section	T0 T1(25d) T2(40d) T3(50d) Tend	Surface	NA	NA	NA	T0 ~ 0 CFU/g ¥ Tend ~ 6.0 CFU/g ¥	NA
Khazzar <i>et al.</i> (2023)	30	75	0.5	3±0.5	Boneless strip loin	T0 T1(7d) Tend	Meat	T0 5.63 T1 5.54 Tend 5.60	T1 0.99 Tend 0.98	NA	T1 0.2 Log ₁₀ CFU/g Tend 0.4 Log ₁₀ CFU/g	T1 0.9 Log ₁₀ CFU/g Tend 1.8 Log ₁₀ CFU/g
DeGeer <i>et al.</i> (2009)	21-28	50	NA	2.2	Loin	T0 Tend	F and M	Shell loin (SH) 5.51 Strip loin (ST) 5.49 21d 5.49 28d 5.49	NA	NA	T0 SH 0.47 Log ₁₀ CFU/cm ² ST 0.06 Log ₁₀ CFU/cm ² Tend SH 1.34 Log ₁₀ CFU/cm ² ST 1.10 Log ₁₀ CFU/cm ²	NA

Li <i>et al.</i> (2013)	14	91	NA	2.9	Muscle <i>Gluteus medius</i>	T0 T1 (14d*) Tend (14d**)	S	T0 5.57 T1 5.62	NA	NA	T0 0.01 Log ₁₀ CFU/cm ² T1 0.4 Log ₁₀ CFU/cm ² T2 0.3 Log ₁₀ CFU/cm ²	NA
Ahntstörn <i>et al.</i> (2006)	14-21	87± 2.6	NA	2.6± 0.4	Strip loin	T0 Tend	F and M	T0 5.4±0.1 Tend 14d 5.5 21d 5.7	NA	NA	T0 < 3 Log ₁₀ CFU/cm ² Tend F 14d 3.3 Log ₁₀ CFU/cm ² F 21d 2.4 Log ₁₀ CFU/cm ² M 14d 5.5 Log ₁₀ CFU/cm ² M 21d 2.7 Log ₁₀ CFU/cm ²	NA
Bernardo <i>et al.</i> (2021)	21	65	2.5	2	Loin	T0 Tend	I	T0 5.39 Tend 5.51	T0 0.993 Tend I 0.9887 S 0.9730	T0 < 1 Log ₁₀ CFU/g Tend 6.22 Log ₁₀ CFU/g	T0 < 1 Log ₁₀ CFU/g Tend < 1 Log ₁₀ CFU/g	NA
							S			T0 < 1 Log ₁₀ CFU/g Tend 2.88 Log ₁₀ CFU/g	T0 < 1 Log ₁₀ CFU/g Tend < 1 Log ₁₀ CFU/g	NA
	21	85	2.5	2			I			T0 < 1 Log ₁₀ CFU/g Tend 7.21 Log ₁₀ CFU/g	T0 < 1 Log ₁₀ CFU/g Tend 5.07 Log ₁₀ CFU/g	NA
							S			T0 < 1 Log ₁₀ CFU/g Tend 10.55 Log ₁₀ CFU/g	T0 < 1 Log ₁₀ CFU/g Tend 8.15 Log ₁₀ CFU/g	NA
Gowda <i>et al.</i> (2022)	21-70	40-75	NA	-1 to +3	Bone-in. mainly loins	T0 Tend	S and I	Tend (steaks) 5.73	Tend (steaks) 0.98-0.99	T0 1.6-8.8 Log ₁₀ CFU/cm ² Tend < 1-7.4 Log ₁₀ CFU/cm ²	T0 < 1-7.3 Log ₁₀ CFU/cm ² Tend < 1-5.0 Log ₁₀ CFU/cm ²	T0 < 1-8.8 Log ₁₀ CFU/cm ² Tend < 1-5.0 Log ₁₀ CFU/cm ²
Van Damme <i>et al.</i> (2022)	42	75-85	NA	2-6	Loin	T0 Tend	F and M	T0 5.50 Tend 5.77	NA	NA	T0 F 1.2 Log ₁₀ CFU/cm ² M <1 Log ₁₀ CFU/cm ² Tend F 1.5 Log ₁₀ CFU/cm ² M 1.9 Log ₁₀ CFU/cm ²	T0 F 2.1 Log ₁₀ CFU/cm ² M <1 Log ₁₀ CFU/cm ² Tend F 4 Log ₁₀ CFU/cm ² M < 1 Log ₁₀ CFU/cm ²
Berger <i>et al.</i> (2018)	28	78	< 0.2	2	Bone-in loin	T0 T1(21d) Tend	Steak (internal)	T0 5.89 Tend 5.79	NA	NA	T1 3.497 Log ₁₀ CFU/ml	NA
Shi <i>et al.</i> (2020)	14	85	1.5	2	<i>Longissimus thoracis</i> muscle	T0 T1(7d) Tend	Inner part	T0 5.41 T1 5.58 Tend 5.61	NA	NA	T0 3.59 Log ₁₀ CFU/g T1 5.73 Log ₁₀ CFU/g Tend 5.29 Log ₁₀ CFU/g	NA

Mikami <i>et al.</i> (2021)	35	90	1.8-2.5	2,9	Rump	Tend	Crust (C) and inner part (I)	5.62	NA	NA	C < 30 CFU/cm ² I 2.03 Log ₁₀ CFU/cm ²	NA
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*before trimming; **after trimming; RH, relative humidity; Vent, air ventilation; a_w, water activity; ¥, data have been retrieved from the figures.