

Behaviour of Quail Meat during Thermal Processing and Technological Implications: A Review

Teofil Stefan VLAD, Georgiana Magdalena GHECIU PIRLEA, Daniela IANITCHI, Stefania Iuliana BOLOLOI, Minodora TUDORACHE

University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Animal Productions Engineering and Management, Department of Production and Processing Technologies, 59 Marasti Blvd., District 1, 011464 — Corresponding author: pirleam337@gmail.com

ABSTRACT: Quail meat (*Coturnix coturnix japonica*) is a valuable source of animal protein with a favourable nutritional profile ($\approx 22.6\%$ protein, 4.5% fat, P/S ratio 1.08, high Fe, Zn and B-vitamins). Despite the steady growth of the global quail industry, its behaviour during cooking remains poorly documented. This review synthesizes published data on physicochemical, structural and sensory changes induced by the main thermal methods (boiling, frying, roasting, grilling, sous-vide), with emphasis on cooking losses (10.0-34.2%), water-holding capacity, denaturation of myofibrillar proteins (myosin 40–60 °C, collagen 53-63 °C, actin 66-80 °C) and the formation of volatile compounds via the Maillard reaction and lipid oxidation.

Internal temperatures of 70-75 °C ensure microbiological safety with moderate cooking losses; high-temperature short-time methods promote Maillard aroma development, while sous-vide minimizes losses and improves tenderness.

Keywords: quail meat, thermal processing, cooking loss, texture, Maillard reaction, volatile compounds

• INTRODUCTION

Japanese quail (*Coturnix coturnix japonica*) is one of the fastest-growing segments of global poultry. The species represents $\sim 11.8\%$ of all domestic birds raised worldwide and $\approx 0.2\%$ of total poultry meat output (200,000-240,000 t/year). The global quail meat & egg market reached USD 0.5 bn in 2024 and is projected to USD 1.2 bn by 2034 (CAGR 8.5%). China dominates ($>80\%$ of output); the EU produces over 100 million quails per year (France, Italy, Spain).

Quail meat is a nutrient-dense matrix: $\sim 22.6\%$ protein, 4.5% fat, 72.7% moisture, 1.1% ash. It provides 11.68 g essential amino acids/100 g protein in pectoral muscle, oleic (41-42%) and linoleic (13-14%) acid, a P/S ratio of 1.08 and high levels of Fe (4.51 mg/100 g), Zn, P, niacin and vitamin B6.

Cooking serves two purposes: ensuring microbiological safety (USDA minimum internal temperature 73.9 °C) and developing sensory attributes through protein denaturation, the Maillard reaction (>140 °C surface), collagen solubilization (53-63 °C) and lipid oxidation. The high oxidative-fibre content of the pectoralis ($\sim 87\%$ red fibres) distinguishes quail from chicken breast.

Aim: synthesize available data on physicochemical, structural and sensory changes induced by boiling, frying, roasting, grilling and sous-vide; integrate quail-specific findings with comparative chicken/turkey data; and identify research gaps to be addressed by dedicated experimental studies.

• MATERIAL AND METHOD

Systematic literature review across Scopus, Web of Science, PubMed/MEDLINE and Google Scholar (January 2005 – March 2026).

Keyword combinations included: "quail meat" AND ("cooking" OR "thermal processing" OR "heat treatment"); "Coturnix" AND ("cooking loss" OR "texture" OR "colour" OR "lipid oxidation" OR "TBARS" OR "volatile compounds" OR "Maillard"); "quail meat quality" AND ("roasting" OR "grilling" OR "frying" OR "boiling" OR "sous vide").

Inclusion criteria: original quantitative data on physicochemical, textural, colour or biochemical properties of quail meat, or comparable data from chicken/turkey under defined cooking conditions. Review articles on heat-induced mechanisms in poultry meat were also retained.

Workflow: ~ 420 records identified \rightarrow 87 full-text articles screened \rightarrow 38 articles retained (22 original quail studies, 12 comparative poultry/meat studies, 4 mechanistic reviews).

RESULTS AND DISCUSSIONS

Cooking loss & water-holding capacity In Japanese quail breast, water-bath cooking (70-74 °C) yields CL of 19.2-24.0% (full range 13.7-34.2%; mean 24.02% in 1,093 pedigreed birds). White-plumaged strains show the lowest CL (19.21%) and highest WHC (22.17%). European quail cooked sous-vide (74 °C, 40 min) shows CL of only 10-11.7%. Quail pH (5.30-6.58) is higher than chicken breast, favouring water retention.

Texture & protein denaturation Mean WBSF of quail breast = 7.75 kg; TPA hardness 14.67 N, springiness 0.97, cohesiveness 0.29. WBSF correlates negatively with pH ($r = -0.62$). Three sequential events drive textural change: myosin (40-60 °C), collagen (53-63 °C, conversion to gelatine) and actin (66-80 °C, primary driver of toughness). The "tenderness window" of 60-65 °C exploited by sous-vide preserves juiciness (see Table 1 and the cascade diagram below).

Colour Raw quail breast: L^* 43-61, a^* 5.5-19.2, b^* -1.7-20.9, depending on strain and age. Heritability of redness is moderate-to-high ($a^* = 0.45$). Above 60 °C oxymyoglobin denatures into grey-brown haemochrome; surface temperatures >140 °C trigger Maillard browning (roasting 175-230 °C, grilling 200-350 °C surface, frying 150-200 °C).

Maillard reaction & volatile compounds 62 volatiles identified in roasted quail at ~ 230 °C (14 aldehydes, 12 N-compounds/pyrazines, 10 alcohols, 8 ketones, 8 acids). Detectable volatiles rise from 31 (0 min) to 51 (40 min); 19 odour-active compounds (OAV >1) are reached at 40 min. Lipid-derived aldehydes dominate quantitatively; pyrazines and Strecker aldehydes drive qualitative differentiation. No single character-impact compound differentiates quail from pheasant, partridge or chicken.

Lipid oxidation TBARS in raw quail: 0.40-0.48 mg MDA/kg (pectoral 0.44; thigh 0.93). Cooked chicken patties reach 1.93 mg MDA/kg, four-fold higher than raw quail. Microwaving and roasting yield the highest TBARS, grilling/frying the lowest among cooked samples. Alpha-tocopherol (1.49 $\mu\text{g/g}$) and dietary antioxidants (e.g. Pleurotus ostreatus, -33.5% TBARS at day 15) modulate stability.

Nutritional changes Apparent protein increases on a wet-weight basis due to moisture loss; total amino-acid mass is largely preserved (83-100% retention). Dry-heat methods promote fat rendering; frying increases fat through oil absorption. Mineral retention 60-70%; boiling causes the greatest leaching. Thiamine is the most heat-sensitive vitamin (38-87% loss during roasting); riboflavin and niacin remain relatively stable.

• CONCLUSIONS

Quail meat behaves during thermal processing as a high-pH, high-PUFA, oxidative-fibre-rich poultry matrix whose textural, chromatic, aromatic and oxidative changes follow general meat science principles but differ quantitatively from chicken and turkey.

The denaturation cascade myosin (40-60 °C), collagen (53-63 °C), actin (66-80 °C) defines a "tenderness window" of 60-65 °C where sous-vide and other low-temperature techniques optimize juiciness while preserving safety.

A high pH (5.9-6.6) favours water-holding capacity, whereas a P/S ratio of 1.08 increases susceptibility to lipid oxidation: cooking method selection therefore implies a trade-off between texture and oxidative stability that has not yet been quantified for quail.

Research gap: no peer-reviewed study has executed a controlled factorial comparison of culinary cooking methods on quail meat with standardized endpoint temperatures. A factorial cooking-method \times temperature \times time trial integrating colour, WBSF, TPA, TBARS, carbonyls, volatile profiling (GC-MS), in vitro digestibility and sensory analysis would generate more foundational data than has accumulated over the last two decades.

Table 1. Texture parameters of quail meat under different thermal treatments (WBSF = Warner-Bratzler Shear Force; NS = not significant).

Reference	Species / Age	Cooking method	Temp. (°C)	WBSF (N or kg)	Hardness (N)	Springiness (cm)	Cohesiveness	Notes
Pedigree quail study	Japanese quail, 35 d	Water bath	~ 74 internal	7.75 kg	-	-	-	n=1,093; mean of pedigreed population
TPA reference study	Japanese quail, 5 mo.	Water bath	70.2	-	14.67	0.97	0.29	Gumminess 4.54 N; chewiness 10.06 N \times cm
Age-effect study	Japanese quail, 6 wk.	Water bath	70.2	Lower (P<0.05)	Lower	Higher	NS (P=0.305)	Young birds significant age \times sex effects
Age-effect study	Japanese quail, 52 wk.	Water bath	70.2	Higher (P<0.05)	Higher	Lower	NS	Spent quail tougher across all shear measures
Comparative poultry	Chicken breast	Multiple methods	Various	6.80–17.08 N	-	-	-	Lowest with high-temp short-time methods
Sous-vide comparison	Chicken breast	Conv. oven vs sous-vide	71 vs 60	29.1 vs 21.7 N	17.3 vs 9.40	-	-	Sous-vide significantly reduced toughness

Thermal denaturation cascade in quail muscle proteins

Sequential transitions define the "tenderness window" exploited by sous-vide cooking

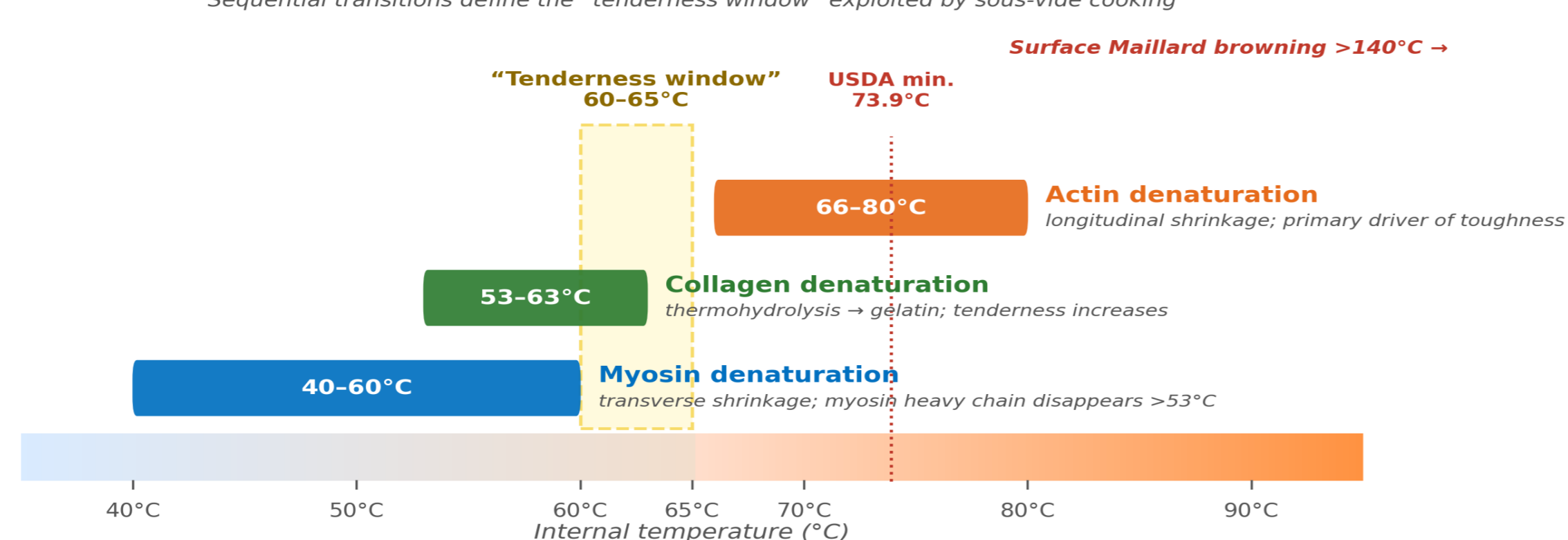


Figure 1. Sequential thermal denaturation cascade of quail muscle proteins, with the "tenderness window" (60-65 °C) and the USDA safety threshold (73.9 °C).

Acknowledgement: The authors gratefully acknowledge the support of the University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Animal Productions Engineering and Management, and thank the editorial team of the Multidisciplinary Conference on Sustainable Development 2026, University of Life Sciences "King Mihai I" of Timisoara.