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Non-thermal technologies for microbial inactivation in fresh blueberries: efficacy, quality effects, regulation and technological readiness

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50
studies included (2015–2026)

3
most studied technologies

1.92–3.96
log_{10} CFU microbial load reduction

32–40 %
lower decay rate

Introduction

Blueberries are valued for freshness, health benefits, and rich organoleptic properties, yet their shelf life is limited by microbial spoilage and enzymatic activity. Thermal treatments are unsuitable because they affect texture, colour, and bioactive compounds. Non-thermal technologies are promising alternatives, but their adoption depends on antimicrobial efficacy, fruit quality effects, regulatory acceptance, and scalability.

Aim

To critically evaluate non-thermal technologies for inactivating spoilage and pathogenic microorganisms on blueberries, their effects on fruit quality, their regulatory status and technological readiness level (TRL).

Material and method

Semi-systematic review of original English-language articles (2015–2026) applying non-thermal technologies to fresh blueberries and reporting microbial outcomes. Quality, nutritional, sensory, and commercial data were recorded as secondary outcomes.

Results and discussions

Fifty studies were included. The most studied technologies were cold plasma (CP), UV-C, and pulsed electric field (PEF).

Aspect	Main finding
Fruit quality	Minimal impact on firmness, colour, and anthocyanins
Scale of use	Mostly specialised or pilot scale
Regulation	Costly and slow; the legal nine-month assessment deadline is routinely exceeded

Conclusions

Non-thermal technologies can improve the microbial safety and shelf life of blueberries. Key barriers to industrial adoption include high operational costs, uniformity of treatment, and the absence of standards and governmental approval. Addressing these gaps is essential to move from laboratory studies to commercial application.

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