Email: biovetinnovator@gmail.com Official Website: https://biovetinnovator.in/
Fueling The Future of Science… ISSN: 3048-8397

Bio Vet Innovator Magazine
(Fueling The Future of Science...)
Volume 3 (Issue 7) JULY 2026
OPEN ACCESS
World Zoonosis Day – 06th July 2026
Popular Article

Cold Plasma: Revolutionizing Meat Preservation and Food Safety

Sangeeta[1], Shubham Dudi[1], Gudia[1], Manisha Choudhary[2]
1Ph.D. Scholar, Department of Livestock Products Technology, LUVAS-Hisar-125004;
2M.V.Sc. Scholar, Department of veterinary Physiology and Biochemistry, LUVAS -Hisar -125004, India
***Corresponding Author:** sangeetalpt28@gmail.com
DOI: https://doi.org/10.5281/zenodo.21458424

Received: July 16, 2026
Published: July 19, 2026

Introduction:

The rising global consumption of meat and the imperative to ensure its safety, quality, and longevity, given meat's susceptibility to microbial contamination and spoilage. Cold Plasma (CP) technology emerges as a prominent solution in this context. CP involves ionizing gas under atmospheric or low-pressure conditions, creating bio-active agents such as reactive oxygen species (ROS) and reactive nitrogen species (RNS), ultraviolet (UV) light, and charged particles, which have demonstrated effectiveness against various microorganisms, thereby maintaining the safety and integrity of various meats and meat products. Cold Plasma offers a non-thermal, environmentally friendly, and efficient method for meat treatment and preservation, ensuring microbial safety while maintaining the food's nutritional and sensory qualities. It has shown potential in inactivating a broad spectrum of microorganisms and ensuring the microbiological safety of meat products without compromising their quality attributes like color, texture, and flavor. Furthermore, Cold plasma technology stands out due to its operational advantages such as quick treatment, easy device operation, low energy requirement, and ability to operate at room temperature, positioning it as a potentially widely adopted technology in future meat processing.

Fundamentals of Cold Plasma Technology:

Plasma, known as the fourth state of matter, is generated when sufficient energy is supplied to a gas, producing a mixture of electrons, ions, free radicals, excited atoms and molecules, and ultraviolet (UV) radiation. Based on its thermal characteristics, plasma is classified as thermal and non-thermal (cold) plasma. Unlike thermal plasma, cold plasma operates at near-ambient temperatures because the applied energy is primarily transferred to electrons rather than the bulk gas (Misra *et al.*, 2019). Cold plasma can be generated under atmospheric or low-pressure conditions, producing reactive oxygen and nitrogen species (RONS) that effectively inactivate microorganisms without significant heat generation. Owing to its non-thermal nature, low water requirement, absence of chemical residues, and use of air as the working gas, cold plasma has emerged as an environmentally friendly technology for improving the safety and shelf life of meat and meat products (Misra *et al*., 2019).

Cold Plasma Formation and Generation:

Cold plasma is produced by applying high-voltage electrical energy to gases such as air, oxygen, or nitrogen, resulting in a partially ionized gas containing electrons, ions, free radicals, UV photons, and reactive oxygen and nitrogen species (ROS/RNS). These reactive species inactivate microorganisms by causing oxidative damage to cellular components without significant heat generation (Pankaj *et al*., 2018). The most common cold plasma generation systems include dielectric barrier discharge (DBD), atmospheric pressure plasma jet (APPJ), and corona discharge. Among these, DBD is the most widely used for food applications due to its efficient surface treatment, while APPJ and corona discharge are primarily employed for targeted surface decontamination (Niemira, 2012).

Applications of Cold Plasma in Meat Processing:

Cold plasma has emerged as a promising non-thermal technology for improving the safety, quality, and shelf life of meat and meat products. It effectively inactivates foodborne pathogens such as *Escherichia coli*, *Salmonella*, *Listeria monocytogenes*, and *Campylobacter*, thereby reducing microbial contamination and extending product shelf life without the use of chemical disinfectants (Niemira, 2012). Owing to its non-thermal nature, cold plasma preserves the nutritional quality, sensory attributes, and natural color of meat while minimizing undesirable changes in texture and flavor (Pankaj *et al*., 2018). In meat processing, cold plasma is widely applied for surface decontamination of fresh and processed meat, sanitation of processing equipment, and sterilization of packaging materials, thereby minimizing cross-contamination and enhancing product safety (Misra *et al*., 2019). Plasma treatment can also modify packaging surfaces to improve barrier properties, seal integrity, and shelf life. Furthermore, cold plasma promotes oxidative modification of muscle proteins and partial collagen degradation, improving meat tenderness and facilitating faster penetration of marinades without affecting the raw characteristics of meat (Pankaj *et al*., 2018).

Regulatory Considerations, Challenges and Limitations:

The commercial application of cold plasma in the meat industry requires compliance with food safety regulations to ensure its safe use in food processing. Regulatory frameworks emphasize the validation of treatment conditions, monitoring of potential reaction by-products, process standardization, and adherence to occupational safety requirements related to ozone and ultraviolet (UV) exposure. Continuous process validation, appropriate operator training, and, where applicable, product labelling is also important to ensure consumer confidence and regulatory compliance (Niemira, 2012). Despite its advantages, cold plasma has several limitations. Its antimicrobial action is largely restricted to the surface of meat, limiting its effectiveness against internal contaminants. Treatment efficacy may vary depending on meat geometry and processing conditions, making uniform application challenging. In addition, large-scale industrial implementation requires substantial investment, and inappropriate treatment conditions may adversely affect sensory quality. Consumer acceptance and regulatory harmonization also remain important challenges for the widespread adoption of this technology (Pankaj *et al*., 2018).

Future Perspectives:

Future developments in cold plasma technology are expected to focus on its integration with artificial intelligence (AI) and Internet of Things (IoT) technologies for real-time process monitoring and optimization. Advances in compact and portable plasma systems will facilitate their adoption in small- and large-scale meat processing facilities. Ongoing research aims to optimize treatment parameters to preserve meat quality while enhancing microbial safety. In addition, increasing emphasis on sustainable, chemical-free processing and consumer awareness is expected to improve the commercial acceptance and wider application of cold plasma technology in the meat industry.

Conclusion:

Cold plasma is an emerging, non-thermal technology with significant potential to improve the safety, quality, and shelf life of meat and meat products. It effectively inactivates foodborne pathogens while preserving the nutritional, physicochemical, and sensory characteristics of meat, making it a sustainable alternative to conventional preservation methods. Its low energy requirement, minimal water consumption, and chemical-free operation further support its application in modern meat processing. However, additional research is required to optimize treatment parameters, evaluate long-term toxicological and packaging safety, and establish standardized regulatory guidelines. Addressing these challenges will facilitate the large-scale commercialization and wider acceptance of cold plasma technology in the meat industry.

References:

Misra, N. N., Schlüter, O., & Cullen, P. J. (Eds.). (2019). *Cold plasma in food and agriculture: Fundamentals and applications*. Academic Press.

Niemira, B. A. (2012). Cold plasma decontamination of foods. *Annual Review of Food Science and Technology, 3*, 125-142.

Pankaj, S. K., Wan, Z., & Keener, K. M. (2018). Effects of cold plasma on food quality: A review. *Foods, 7*(1), 4.

Citation: Sangeeta, Shubham Dudi, Gudia, Manisha Choudhary. (2026). Cold Plasma: Revolutionizing Meat Preservation and Food Safety. In Bio Vet Innovator Magazine (Vol. 3, Issue 7, pp. 69–71). Bio Vet Innovator Magazine. https://doi.org/10.5281/zenodo.21458424