

Pulsed Electric Field Technology: A Promising Approach for Fish Preservation

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Fish and fishery products are the most nutritious food due to the presence of essential fatty acids, vitamins, minerals and a source of high-quality animal protein for humans. On the other hand, fish is highly perishable because of the high moisture content, presence of unsaturated lipids, spoilage microorganisms, and enzymes (Kumar et al., 2024). Conventional preservation methods such as icing, freezing, drying, salting, smoking, and canning have been widely used for decades. However, these methods are effective in spoilage reduction often come with many drawbacks, including quality degradation, nutrient loss, undesirable changes in colour, texture, and flavour, high energy consumption, high cost and environmental impact etc. (Bashir et al., 2026). Furthermore, these conventional methods are not allied with consumer demands such as fresh-like, minimally processed food with nutritional integrity. In recent years, there has been growing interest in non-thermal technologies that can extend shelf life of foods while preserving the fresh-like quality and nutrients. One such non-thermal emerging technology is Pulsed Electric Field (PEF) treatment which can maintain nutritional and sensory qualities while enhancing safety and quality of fish and fishery products.

Pulsed Electric Field technology involves the application of short bursts of high-voltage electric fields to food placed between two electrodes. Unlike thermal processing, PEF does not rely on heat to inactivate microorganisms. Instead, it works by disrupting the cell membranes of microorganisms through a process known as electroporation. This leads to the leakage of intracellular components and ultimately results in microbial inactivation. Because the treatment is non-thermal and applied for only microseconds to milliseconds, the overall impact on the sensory and nutritional quality of fish is minimal.

Potential applications of PEF in Fish preservation

One of the most significant advantages of PEF in fish preservation is its ability to reduce microbial load without affecting the natural characteristics of the product. Studies have shown that PEF

treatment can effectively inactivate spoilage bacteria and certain pathogens, thereby extending the shelf life of fresh and minimally processed fish. This is particularly beneficial for high-value seafood products where maintaining texture, color, and flavor is critical. Unlike conventional heat treatments, PEF preserves delicate compounds such as omega-3 fatty acids and prevents protein denaturation. PEF treatment preserves sensitive compounds, maintains the natural texture and color of foods, and reduces energy consumption (Bashir et al., 2026). Furthermore, PEF treatment can enhance the extraction yield of proteins, lipids, and bioactive compounds from marine biomass such as fish skin, bones, and viscera, etc. (Ahmed et al., 2025). This supports better utilization of processing waste and aligns with the growing emphasis on sustainability and resource efficiency in the seafood sector. In addition, PEF has been reported as a promising technology to improve water-holding capacity, tenderness, and texture of fish muscle (Guo et al., 2024).

Moreover, PEF has also shown potential as a pre-treatment method in fish processing operations. For instance, it can enhance mass transfer during drying by increasing cell permeability, thereby reducing drying time and energy consumption (Liu et al., 2025). Similarly, in processes such as salting and marination, PEF can improve the penetration of salt and other additives, leading to more uniform product quality. These advantages make it an attractive option for improving process efficiency in the fish processing industry. A recent comprehensive review (Kumar et al., 2026) highlights that PEF is emerging as a viable green technology for producing safe, high-quality, and sustainable fish products with lower energy requirements.

Despite its advantages, the adoption of PEF technology in fish processing is still at a developing stage. High initial investment costs, the need for specialized equipment, and challenges in treating solid and thick tissues are some of the limitations that need to be addressed. In this regard, ICAR-CIFT has initiated the research work on the development of PEF system for fish and fishery products treatment which will make PEF

more accessible and economically viable for fish preservation in the near future. The schematic representation of the PEF system which is aimed to be developed is shown in Fig. 1.

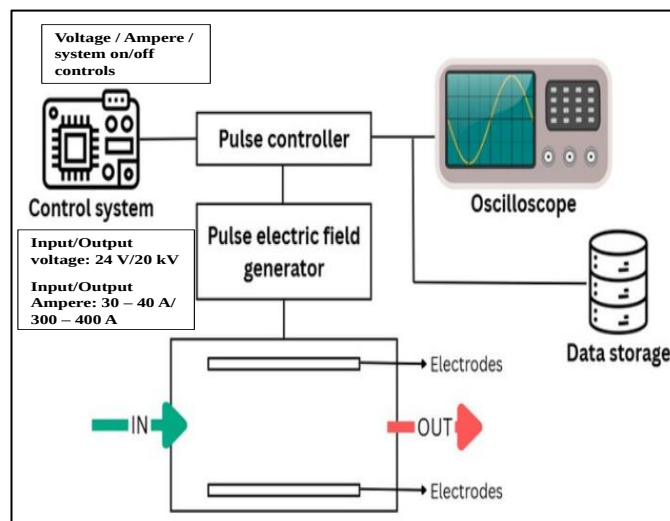


Fig. 1: Schematic of the components of PEF system

Conclusion

Pulsed Electric Field technology represents a promising, energy-efficient, and quality-preserving alternative to conventional fish preservation methods. Its ability to extend shelf life, maintain nutritional quality, and enhance processing efficiency makes it particularly suitable for modern seafood processing systems. As the industry moves towards sustainable and high-quality food production, PEF is likely to play an increasingly important role in shaping the future of fish preservation. Its wider adoption could enhance food safety and quality while supporting circular bioeconomy practices and reducing environmental impact.

References

- Ahmed, M., Ranjan, H., & Roy, S. (2025). Pulsed electric fields for sustainable meat, poultry, and fish processing: Recent advances, prospects, and industry challenges. *Innovative Food Science & Emerging Technologies*, 102, Article 104008. <https://doi.org/10.1016/j.ifset.2025.104008>
- Bashir, K. M. I., An, H. R., Mansoor, S., Shin, H., Luzi, G., Sohn, J. H., & Choi, J. S. (2026). Innovative Applications of Pulsed Electric Field Technology in Marine Biomass Processing. *Food and Bioprocess Technology*, 19(1), 19. <https://doi.org/10.1007/s11947-025-04119-7>
- Kumar, P., Chauhan, S., Das, D., Mohapatra, N., Dandapath, P., & Naznin, S. (2026). Pulsed Electric Field Processing for Fish Preservation: A Review. *Journal of Advances in Biology & Biotechnology*, 29(1), 42-54. [10.9734/jabb/2026/v29i13505](https://doi.org/10.9734/jabb/2026/v29i13505).
- Kumar, P., Vaishnav, A., Chauhan, S., Lalbiaknguri, S., Lal, J., Singh, N. S. C., & Pati, B. K. (2024). Encapsulation techniques for enhancing the stability and bioavailability of food: A review. *Int. J. Adv. Biochem. Res.*, 8, 16-23. <https://doi.org/10.33545/26174693.2024.v8.i3Sa.681>

- Liu, Y., Berrada, H., Wang, M., Zhou, J., Kousoulaki, K., Barba, F.J., & Castagnini, J. M. (2025). Is pulsed electric field (PEF) a useful tool for the valorization of solid and liquid sea bass side streams?: Evaluation of nutrients and contaminants. *Food and Bioprocess Technology*, 18, 1873–1892. <https://doi.org/10.1007/s11947-024-03553-3>