AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 02 Issue: 10 October 2021 Article No: 25

The novel Non-Thermal Technology: Cold Plasma Technology

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SUMMARY

Fish is world-favoured and an important food but has a short shelf-life due to its extremely perishable. Thermal processing is the most common food processing procedure that may kill microorganisms but can deteriorate physicochemical and sensory quality, particularly in temperature-sensitive foods. Non-thermal methods, particularly cold plasma, are getting popular as a promising technique for minimally processed foods, particularly seafood in which achieve the consumer demand with increased stability and better nutritional and organoleptic characteristics. However, there are some drawbacks to these technologies, including protein oxidation, lipid oxidation, changes in organoleptic characteristics, and discolouration, which restrict their use in the seafood industry. To avoid these issues, combining Cold plasma treatment with antioxidants has shown to be a beneficial strategy.

INTRODUCTION

Any food product's quality is determined by its quantitative and qualitative properties, as well as the perception of the consumer. Thermal processing technologies such as sterilization, high-temperature drying, pasteurization, and other food preservation procedures have created a major role during the last two decades. Even though these processing procedures extend the shelf life of foods, they have been associated with several disadvantages, such as texture, flavour, and colour changes, as well as nutritional losses due to overheating. As a consequence, non-thermal processing methods emerged to overcome these limitations. Non-thermal preservation techniques provide a balance between safety and minimum processing, cost limitations and acceptable quality. Cold plasma has been introduced as a novel non-thermal food technology that broadly aims to offer pasteurization effects without the use of heat. Promise to process food without the negative effects of thermal processing. Due to its strong inhibitory efficiency against a wide range of microorganisms, Cold plasma technology has recently been recognized as a viable non-thermal preservation method for seafood.

What is Cold Plasma?

Plasma is the fourth state of matter apart from solid, liquid and gas (Fig: 1). Plasma can be obtained from various sources of energy including radioactive (gamma radiation), electrical, X-ray, optical (UV light), and thermal energy, which are capable of ionizing the gases. The produced reactive species are responsible for the antimicrobial properties of Cold Plasma. Cold Plasma (CP) is both technologically and economically feasible as a food processing technique, because of technological advancements that allow for process scalability and the use of ambient air as the inducer gas.
There are three possibilities for how the produced plasma species is delivered to the target.

I)Direct exposure: Refers to exposing the food directly to the plasma discharge. This might be a plasma jet plume or the field created by two electrodes with short-lived reactive species.
Indirect exposure: The target is placed some distance away from the plasma discharge in this method with relatively long-lived species. This method might be beneficial in minimizing the negative effects of direct exposure on weak or vulnerable tissue.

Plasma-activated water: A fluid (usually water) is used as a delivery medium for plasma-generated reactive species in this method. When solutions are exposed to plasma, they produce relatively long-lived secondary products including hydrogen peroxide, nitrates, and nitrites, which can effectively affect the microbes.

Based on their compatibility with the food system, Jet plasma (Fig: 3. a) and Dielectric barrier discharge (Fig: 3. b) can be adopted as an alternative approach for seafood preservation.

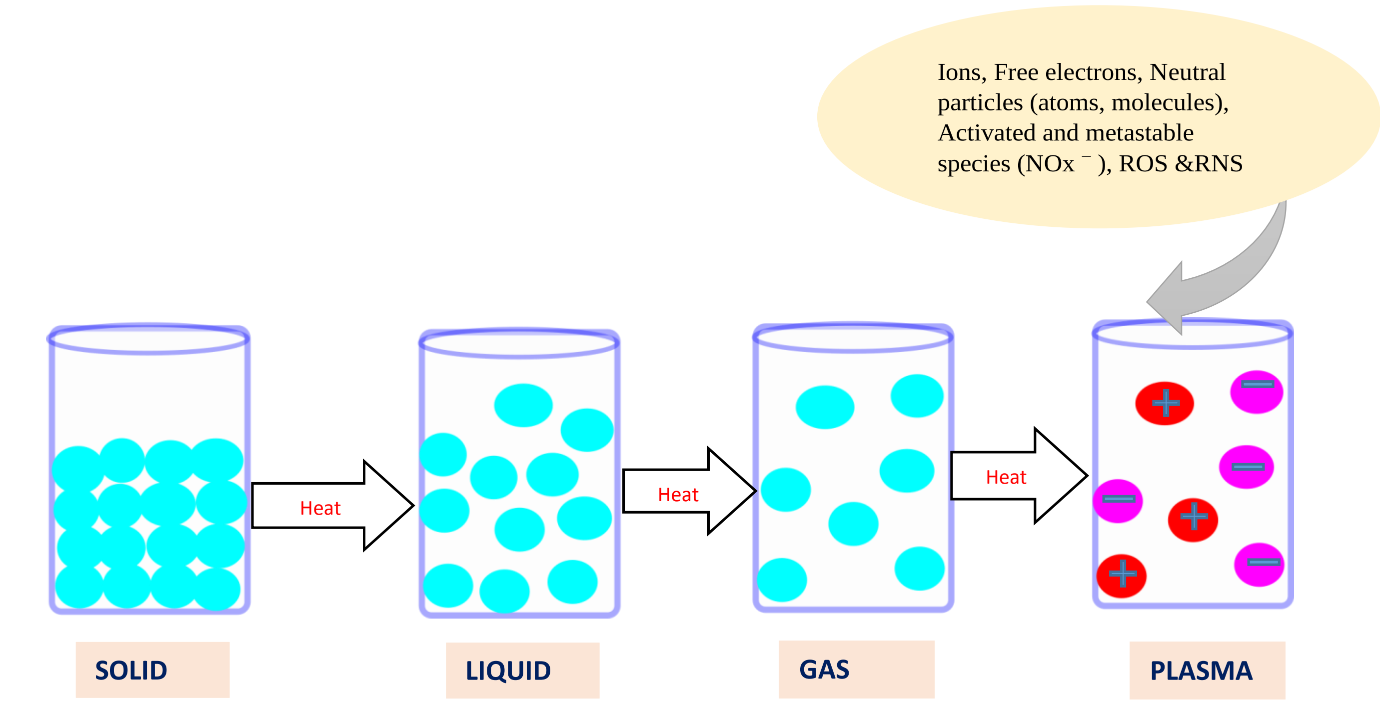


Fig: 1 Plasma fourth state of matter

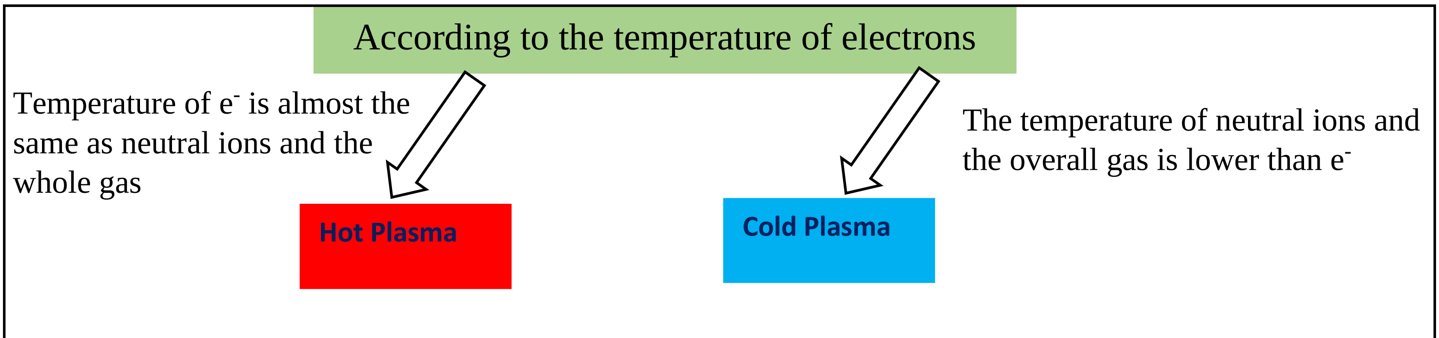


Fig: 2 Types of plasma based on temperature of e^-

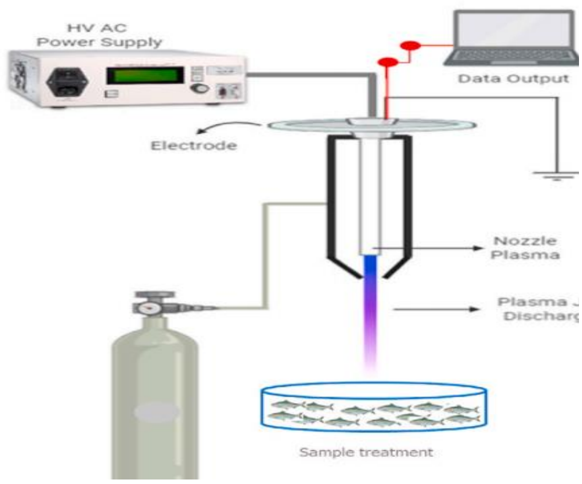


Fig:3.a Jet plasma (JP)

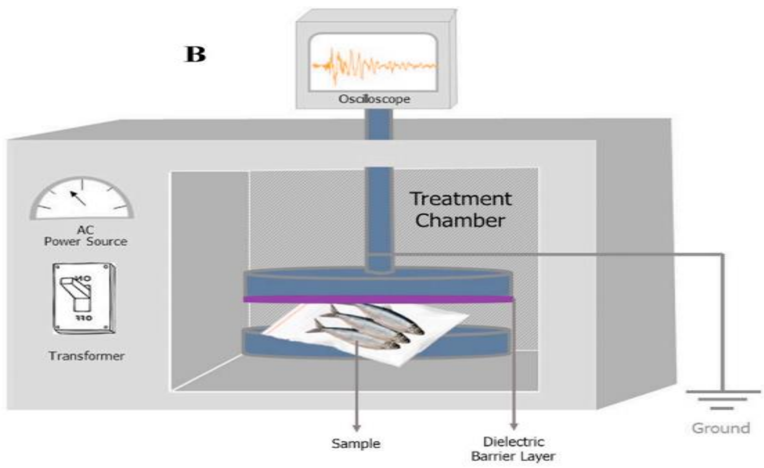
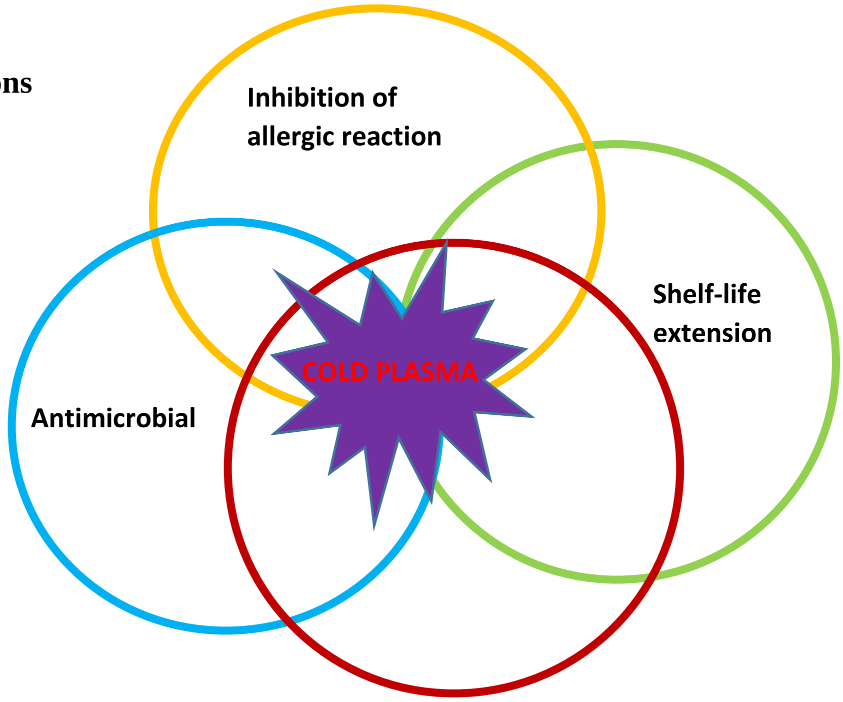


Fig:3.b Dielectric barrier discharge (DBD)

Because of the increased demand for fresh chilled foods, CP technology was implemented. However, extremely fresh kinds of seafood are practically preferred for treatment to preserve their best quality.

Applications



Antimicrobial activity

Cold plasma therapy has been investigated and shown to have antimicrobial effects on a wide range of microorganisms, including Gram-positive and Gram-negative bacteria, vegetative cells, biofilms, and spores. Plasma inactivates microbes by gradually oxidizing fundamental cellular components, damaging the bacterial membrane, and destroying cell lipids, proteins, and DNA, resulting in microbial cell damage or death.

Shelf-life extension

To maintain food security and reduce waste, product shelf-life extension has been recognized as a worldwide problem. Plasma reactive species, primarily hydroxyl radicals (OH•), superoxide anion radicals (O 2 •), hydroperoxy radicals (HOO•), and nitric oxide (NO•), are linked to chemical changes, resulting in the loss of enzyme function. As a result, cold plasma technology can extend shelf life.

Food waste processing

Seafood processing effluent has large levels of organic matter, which can pollute water. These effluents are often treated using physicochemical or biological techniques that are ineffective in removing organics. Cold plasma oxidation has recently emerged as a potential technique for removing aqueous and gaseous pollutants. Plasma can be used with biological treatment to increase the efficiency of the procedure.

Inhibition of Allergenicity

Non-thermal techniques for decreasing food allergenicity have recently been investigated due to their minimal impacts on food quality indicators. An immunoglobin (IgE)-mediated response to antigens (mostly proteins), causes food allergy. The epitope site is the location where an antigen binds. The epitopes discovered in food allergens can be changed to prevent allergic responses. Proteins that are securely bound to solid surfaces can be removed using cold plasma, which changes the structure of the protein. Cold plasma treatment suppressed IgE binding to tropomyosin and shrimp extract. They further suggested that the free radicals produced by plasma exposure might mask or distort the conformational binding epitope, eliminating the IgE-mediated reaction that would otherwise trigger a negative immunological response.

Food functionalization

Plasma treatment has recently been demonstrated as a novel method for starch modification. Plasma treatment induces changes in the crystallization and gelatinization of starch. Enhanced WHC is one of the desired characteristics of seafood connected to juiciness and delicate texture, and the influence of Cold Plasma on the WHC of seafood

Key Challenges

- Treatment of bulky and irregularly shaped food is difficult
- Another concern is the lack of a measured dosage for food items.
- Almost all research in the literature have been conducted on a laboratory size; however, efforts to scale up are continuing.
- Lipid oxidation is one of the limitations of using Cold plasma to treat lipid-rich foods, especially seafood, which is high in mono & polyunsaturated fatty acids.
- Protein oxidation mediated by Cold plasma-produced reactive species leads to the technology's limitations in the seafood sector.

CONCLUSION

The constraints, particularly the increased protein and lipid oxidation, have been a key obstacle to overcome. To avoid these issues, combining Cold plasma treatment with antioxidants has shown to be a beneficial strategy. Using a combination of Cold plasma and antioxidants or other technologies, Protein oxidation and Lipid oxidation, as well as colour changes and sensory characteristics of seafood, might be delayed or minimized. Cold plasma technology is gaining interest among researchers as a promising non-thermal technology. There is a great necessity for further study in the above consequences so that cold plasma could be a breakthrough technology for future food preservation. Still many opportunities remain to be harnessed for further research and development to meet the demand for plasma technological application in the food sector.

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