AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 04 (April, 2026)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

Cold Plasma: A Novel Non-Thermal Technology

*Vinay G M and Pathiam Srilatha
Department of Food Process Technology, College of Food Science & Technology,
Professor Jayashankar Telangana Agricultural University, Rudrur, Telangana, India
*Corresponding Author's email: vinaygm26@gmail.com

Cold plasma is a promising technology that can improve food safety. This method employs reactive gases that are energetic enough to neutralize any harmful microbes on meats, poultry, fruits, and vegetables. Because it is non-thermal, cold plasma treatments do not significantly affect the physical, chemical, nutritional, or sensory attributes of the treated products. It is used to deactivate undesirable microorganisms and ensure the safety of food for the consumer. Michael Faraday pioneered the development of a high voltage DC electrical discharge tube in the 1830s. In the 1850s, the Siemens Company harnessed the power of dielectric discharge to generate ozone and purify water of microorganisms and their toxins. English physicist Sir William Crookes identified plasma as a fourth state of matter in 1898. Dr. Irving Langmuir coined the term "Plasma" in 1928 to describe an electrically neutral collection of ions and electrons, potentially containing neutral gas, capable of reacting to electric and magnetic fields.

Principle

While there are three distinct states of matter on Earth—solid, liquid, and gas—there is also an abundant fourth form of matter in the cosmos known as "plasma."The state of ionised gas known as plasma consists of free electrons, positively and negatively charged ions, and activated neutral species (excited and radical). Based on these differences, plasma is often divided into two types: warm plasma and cold plasma. Electrons or photons that impact with the neutral atoms and molecules in the feed gas with enough energy evict one electron from their outer shell, producing plasma that contains both positive and negative ions, which are charged particles. An electrical discharge into a gas excites some of the molecules, increasing their Brownian motion and causing collisions that release electrons from the atom's outermost shell, producing positive and negative ions, free radicals.

Applications of Cold Plasma in Food Industries

1. Inactivation of micro-organism

Daniela Bermúdez-Aguirre (2013) examined the effects of cold plasma discharges from a needle array at atmospheric pressure, ranging from 3.95 kV to 12.83 kV (60 Hz) in argon, for a duration of 30 s to 10 min. Following processing, Hunter's color characteristics and microbiological quality were evaluated. The degree of inactivation was influenced by the inoculation level, as the bacteria were simpler to inactivate at lower numbers, according to the results. Moreover, the greatest treatment duration and maximum voltage.

2. Effect on Physio-chemical and Antioxidant properties

Throughout the storage period, there was an increase in dry matter and a decrease in soluble solid content of the plasma-treated samples, as well as a significant decrease in titratable acidity. These qualitative parameters included soluble solid content, titratable acidity, dry matter, and color change. Treatments by Ramazzina *et al*. (2015) During four days of controlled storage, the effects of storing kiwi fruits for 10 and 20 minutes on each side were assessed by keeping an eye on criteria pertaining to texture, visual quality, chlorophyll,

carotenoids, and polyphenols. The results showed that plasma treatments had no effect on the product's texture and instead improved color retention and decreased the creation of darker areas during storage, all of which helped to maintain the product's quality. Treatments with plasma produced an instant.

3. **Effect on enzyme**

Enzymatic browning, which reduces the quality of a food product, is the main problem with fresh cut fruits and vegetables. After treating the samples for 10, 20, and 30 minutes, the best outcomes were a 30-minute reduction in browning area of almost 65% when compared to control samples. The chemical interactions between the protein structure and plasma species, as well as the plasma parameters, determine how effective inactivation is. Kang *et al*. (2019) examine the effects of microwave cold plasma (CP) treatment on inactivation of polyphenol oxidase (PPO) of potato. The optimum CP-generation power and treatment time for inactivating PPO in the PPO extract were found to be 900 W and 40 min, respectively, which resulted in the highest inactivation of PPO (49.5%).

4. Seed Germination

Application of plasma has been reported to have an effect on the germination of soybean, peas, corn, buck wheat seed, etc. The effect of cold plasma chemistry technology to enhance the delay of seed germination by coating with CF4 and octadecafluorodecalin. Before seeding, 0, 60, 80, 100, and 120 W of cold plasma were applied for 15 seconds. The outcomes demonstrated that plasma treatments improved seed germination and seedling development, and that treating 80 W had he highest stimulatory effect. Germination and vigor indices significantly increased by 14.66% and 63.33%, respectively.

5. Effect on Starch Granules and its Modification

Sun *et al*., (2022) examined the effects of treating rice starch with microwave radiation for 30 and 90 seconds or cold plasma radiation for 2, 6, and 10 minutes on its structural, physicochemical, and digesting characteristics. The results were compared with the effects of treating rice starch with both radiation and cold plasma combination. The dual alteration of starch with combined MW and CP treatments resulted in a considerable change in the shape, and starch had reduced peak viscosity, swelling power, and crystallinity.

6. Effect on Phenolic and Antioxidant Compounds

The study conducted by Amini and Ghoranneviss (2016) found that the antioxidant activity and total phenolic content of both fresh and dried walnuts were unaffected by the 11-minute plasma jet treatment. All cultivars exhibited the same level of total phenolic and antioxidant activity following plasma jet treatment. Following 15 and 30 days of storage (4°c), an increase in the total phenolic content and antioxidant activity was noted in the treated and control samples.

Advantages

1. This technique is applicable to both solid and liquid food products.
2. This method reduces the use of preservatives.
3. It does not require water or other chemical solvents, thus it is also considered environmentally friendly.
4. Cold plasma does not leave any residue.
5. It doesn't affect nutrients and vitamins within the food.
6. This process operates at ambient temperature (ideal for thermo-labile products)

Disadvantages

1. Plasma technique is not suitable for high fat products.
2. The cost of the plasma processing is large.
3. Cold plasma is not used for inactivation of endogenous enzymes, which are present intact in the whole fruits because plasma effect is a surface phenomenon.

Conclusion

Cold plasma is an emerging novel technology in the recent era. It is gaining fame for its unique characteristics like treatment in low or ambient temperature for a short period of time which helps in retaining the integrity and quality of food products. It has proved to be efficient in sanitizing equipment for inactivating the foodborne pathogens from fresh produce and packaging materials.

References

1. Amini, M., & Ghoranneviss, M. (2016). Effects of cold plasma treatment on antioxidants activity, phenolic contents and shelf life of fresh and dried walnut (Juglans regia L.) cultivars during storage. *Lwt*, *73*, 178-184.
2. Bermúdez-Aguirre, D., Wemlinger, E., Pedrow, P., Barbosa-Cánovas, G., & Garcia-Perez, M. (2013). Effect of atmospheric pressure cold plasma (APCP) on the inactivation of Escherichia coli in fresh produce. *Food Control*, *34*(1), 149-157.
3. Kang, J. H., Roh, S. H., & Min, S. C. (2019). Inactivation of potato polyphenol oxidase using microwave cold plasma treatment. *Journal of Food Science*, *84*(5), 1122-1128.
4. Ramazzina, I., Berardinelli, A., Rizzi, F., Tappi, S., Ragni, L., Sacchetti, G., & Rocculi, P. (2015). Effect of cold plasma treatment on physico-chemical parameters and antioxidant activity of minimally processed kiwifruit. *Postharvest Biology and Technology*, *107*, 55-65.
5. Sun, X., Saleh, A. S., Sun, Z., Ge, X., Shen, H., Zhang, Q., ... & Li, W. (2022). Modification of multi-scale structure, physicochemical properties, and digestibility of rice starch via microwave and cold plasma treatments. *Lwt*, *153*, 112483.