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Applications of cold plasma technology in food sector

Rehana Salim[1*], Furheen Amin[2],Fiza Nazir[1]

[1]*Division of Food Science and Technology, SKUAST-K, Shalimar, Srinagar, J&K, India- 190025*

[2]*Department of Food Science and Technology, University of Kashmir, Srinagar, J&K, India-190006*

ABSTRACT

Cold plasma technology is a modern non conventional technique that uses energetic, reactive gases to inactivate contaminating microbes on meats, poultry, fruits, and vegetables. It is an eco-friendly process which is used in the preservation of food and other potential applications as an alternative to common techniques. This technology is the prime consideration in food processing industries viz. post-harvest, meat, packaging etc. Cold plasma plays an important role in decontamination of food and packaging materials from microorganisms, manufacturing of packaging materials, active packaging and retards browning reactions.

Key words: Cold Plasma, Food, Processing

I INTRODUCTION

Food has long been associated with numerous food borne diseases. Food safety is one of the major concerns prevailing for the food industries, regulatory bodies and customers. Pathogenic microorganisms are a major hassle concerning the food processing industries as they have an unfavorable impact on the health and economy of the public [1]. Techniques including pasteurization, autoclaving, canning and steam sterilization are used to eliminate pathogenic microbes. However, they possess several side effects viz. nutritional loss, effect sensory properties and degrade functional properties of the food. To overcome these side effects various cold processing techniques have been introduced [2]. Increasing demand for fresh produce among consumers poses a challenge to the food industry of supplying safe food with minimal processing. There is much interest in novel ways of preserving food and destroying micro-organisms without affecting its quality. Cold plasma is one such technique that has potential in the food processing sector to inactivate microorganisms, thereby improving food safety [3]. This article reviews the applications of cold plasma technology in food processing sector.

1.1COLD PLASMA

I. Langmuir [4] first used the term plasma and defined it as the fourth state of matter which is partially or wholly ionized state of gas. He discovered plasma oscillations in ionized gas. Plasma is considered as a distinct state of matter due to its properties; it does not have a regular shape or volume and can form filaments and/or beams under magnetic fields [5]. Primarily based on the mechanism of generation, plasma is classified into two types: High temperature plasma which implies that electron, ions and neutral species are in a thermal equilibrium state and Low temperature plasma that is subdivided to thermal plasma, also called local thermodynamic equilibrium plasmas (LTE) and non thermal plasma (NTP), also called non-local thermodynamic equilibrium plasmas (non-LTE). The main characterization of thermal plasmas (TP) is an equilibrium among electrons, ions and neutrals. In generation of cold plasma most of the coupled electrical energy is channeled to electron component rather than heating whole gas stream so the temperature of heavy particle remains near the room temperature, these characteristics make it suitable to be used in processes in which high temperature is not desirable [3].

1.2GENERATION OF COLD PLASMA

Plasma can be generated by subjecting a gas to an electric field (between two electrodes), either of constant (direct current field) or alternating amplitude (usually high frequency field). Plasma state can be attained via utilization of energy in several forms including; thermal, electric or magnetic fields and radio or microwave frequencies, which boom the kinetic energy of the electrons resulting in increased number of collisions in the gas forming plasma products like electrons, ions, radicals and radiation of varying wavelengths inclusive of that within the UV ranges. The numerous strategies used for plasma generation includes the corona discharge, dielectric barrier discharges (DBD), radio frequency plasma (RFP) and the gliding arc discharge [6]. Cold plasmas, including lowpressure DC and RF discharges (silent discharges), discharges from fluorescent (e.g., neon) illuminating tubes, DBDs may be found both at low pressure or atmospheric pressure [7]. The dielectric barrier discharges (DBDs) are historically refered to as 'silent discharges'. They also operate at approximately atmospheric pressure (typically 0.1–1 atm). An A.C. voltage with amplitude of 1–100 kV and a frequency of a few Hz to MHz is applied to the discharge, and a dielectric layer (made of glass, quartz, ceramic material or polymers) is again placed between the electrodes. When a potential difference is applied between cathode and anode, a continuous current will flow through the discharge; giving rise to direct current (D.C) glow discharge. Capacitively coupled (CC) radio-frequency (RF) discharges are produced whilst alternating voltage is applied between the two electrodes, in order that each electrode will act alternately as the cathode and anode. The frequencies usually used for those alternating voltages are typically in the radiofrequency (RF) range (1 kHz–103 MHz; with a most common value of 13.56 MHz). Non thermal gas discharges at atmospheric pressure are of interest for the food industries as they don't subject the food system to extreme conditions.

1.3APPLICATIONS OF COLD PLASMA

Cold plasma can be successfully used for microbial destruction on fresh products to increase shelf life. Feichtinger et al. [8] reported cold plasma technology as alternative source for surface sterilization and disinfection process which can act on both vegetative cells and spores with shorter periods of time. The chemical composition of plasma contains free radicals, highly reactive species and radiations are often generated in varying range from UV to visible. It is believed that the role of different constituent depends on the gas and operating pressure. The destruction of microbial DNA by UV irradiation, volatilization of compounds from spore, so-called "etching" of the spore surface by adsorption is because of reactive species like free radicals [9].

Potential application in food NTP has been applied in the food industry including decontamination of raw agricultural products (Golden Delicious apple, lettuce, almond, mangoes, and melon), egg surface and real food system (cooked meat, cheese). Pasquali et al. [10] reported the effect of cold plasma on red chicory (*Cichoriumintybus*) treated with atmospheric cold plasma kept at a difference of 70 mm from discharge. The conditions were kept stable with a temperature of 22°C and 60% RH, only treatment time varied for 15 and 30 min. The load of *E. coli* and *L. monocytogenes* at the initial stage was 108cfu/ml and 1.2 x 108 to 1.6 x 108cfu/ml respectively, treated for 15 min and 30 min, respectively. In 15 min of atmospheric cold plasma treatment *E. coli* reduced to 1.35 log MPN/cm2 whereas, *L. monocytogenes* took 30 min to have a final load of 2 log cfu/ml.

The plasma technology is offering high potential in food packaging as it enhances the adhesion properties, polymerization and helps in good printability [11]. Low temperature gas plasma sterilization allows fast and safe sterilization of packaging materials such as plastic bottles, lids and films without adversely affecting the properties of the material or leaving any residues. Cold plasma can be utilized for sterilization of heat sensitive packing materials like polythene ethylene and polycarbonate as the temperature is low [12]. The active packaging of red delicious apples were done using plasma reactor known as atmospheric pressure cold plasma reactor (APCPR), atmospheric pressure cold plasma was achieved by increasing the voltage between needle-to-needle configuration. Argon was chosen as carrier gas and vanillin was taken as a monomer as it has the ability to form plasma polymerized films. The chamber which was kept below the zone of activation was used to treat the apple for proper deposition of film on the apple surface The study concluded that smooth thin layered film can be deposited in the apple surface however nodules were observed which can occur during the condensation of vanillin powder after sublimation [13]. Oh et al. [14] prepared edible film treated with cold plasma which was based on defatted soybean meal and had better tensile strength, elongation and moisture barrier than control.

The major problem with the fresh cut fruits and vegetables is enzymatic browning which affects the quality attributes. Bubler et al. [15] showed the impact of plasma processed air on polyphenol oxidase and peroxidase enzymes present in apples and potatoes. The cut apple and potato tissue were treated for 10 min with plasma processed air which showed reduction of polyphenol oxidase up to 62% and 77% respectively, peroxidase reduced about 65% in cut apple and 89% in potato tissue.

Numerous authors reported the early germination of seeds can be achieved by treating the seeds with plasma. This is due to active particles that penetrates through the seed coat and directly influence the cells inside. Sera et al. (2012) found that germination rate of plasma treated wheat was quick and germination occurred first in plasma treated seeds then in untreated seeds.

II CONCLUSION

Cold plasma is an emerging non-thermal technology that helps in maintaining the integrity and quality of food products. The technique is effective at ambient temperatures, thus minimizes the thermal effects on nutritional and sensory quality parameters of food. Cold plasma is responsible for microbial destruction and surface modification of substrate as conventional preservatives techniques as some detrimental effects on nutritional quality. Cold plasma has proved to be efficient in sanitizing equipment for inactivating the foodborne pathogens from fresh produce and packaging materials. it also helps in retarding browning reactions in fruits and vegetables. Future studies should be directed towards assessment of the efficacy of cold plasma on the processing of different food products.

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