COLD PLASMA: EMERGING NON-THERMAL TECHNOLOGY IN FOOD PROCESSING

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Abstract:

It was observed that since many years cold plasma technology was used for sensitive materials but now a days trend it moving towards the disinfection of food materials too. While maintaining quality of fresh food commodities cold plasma technology has been seen as advantageous for inactivation of the micro organisms. Looking towards the improvement of food safety Cold plasma is an emerging non thermal technology. Cold plasma is a novel and emerging non thermal technology that uses energetic, reactive gases for the inactivation of spoilage micro organisms on meats, poultry, fruits and vegetables commodities. This technology is used for purification and disinfection of fruits and vegetables without changes in organoleptic properties. Developing interest for fresh produce represents the challenge to the food business of providing safe and secure food with negligible processing and treatments. Cold atmospheric plasma has potential in the food manufacturing area to inactivate microorganisms, accordingly enhancing sustenance and security without loss of physicochemical or organoleptic properties. The present investigation is carried out to understand the importance, microbial inactivation mechanism current status as well as different aspects of cold plasma technology. Different applications of cold plasma technology are also analysis with emphasis on food and agro based applications.

Keywords: *Cold Plasma Technology, Food Processing, Agricultural produce, emerging non thermal technology.*

Introduction :

Everything surrounding to us is known as universe and the matter present on earth mostly found as solid, liquid and gas among this the fourth states of matter is Plasma. The discovery of the term 'Plasma' was first carried by scientist Irving Langmuir in 1928.Then he defines plasma as the fourth state of matter which is the combination of partially or wholly ionized gases [1]. With the consideration of various properties of the plasma, its application in the different fields which include textile, electronics, life sciences, packaging etc [2]. For the surface disinfection of fruits, seeds, and spices the sterilisation methods such as heat, chemical solution are used but they are very time-consuming and there is effect on the nutritional content. Looking towards the conventional techniques like heat, chemicals and UV treatment Van de Veen et al. reported that the activity of cold plasma is more on the bacterial spore. The spoilage of the food commodity is occurs due to the activity of different food enzymes and contamination by different micro organisms . In the food industry the presence of pathogenic micro organisms is responsible for causing health risks [3,4]. Hence the control of these microbes is very important in the food industry. For the destruction of infectious microbes There are a various methods such as: thermal technologies, which include sterilization, pasteurization, ohmic heating, etc. and non-thermal technologies, include high hydrostatic pressure, pulsed electric fields, high voltage arc discharge [3,4]. The thermal technologies are responsible for the change in quality attributes and loss of essential nutrients, while the non thermal technologies are expensive and for the processing skilled and trained personnel required hence for applying in the processing it is technically difficult. ACP: atmospheric cold plasma, a non-thermal plasma

technology, is proposed as a potential alternative to traditional methods for decontamination of foods [5]. This technology does not require extreme process conditions and offers great opportunities for food product preservation [5], where the heat is not desirable for it in conjunction with maintenance of sensory attributes of the treated foods. This article briefly summarizes relevant aspects of ACP including plasma generation, microbial inactivation mechanism and plasma applications in food processing.

Cold atmospheric plasma has potential in the food processing area to inactivate microorganisms, there by enhancing food safety and security [1]. Developing interest for fresh produce represents the challenge to the food business of providing safe food with insignificant handling treatments. It is pivotal that foods are provided with no microbial contamination as numbers of products are eaten in its raw form. Subsequently, there is much enthusiasm for novel methods for safe foods and killing micro organisms without influencing its quality. One such developing innovation that has indicated guarantee is the utilization of cold atmospheric plasma (CAP) technology. An overview of the cold plasma technology is presented with its potential applications in food processing sector. Among the all states of matter Plasma is considered as the fourth state of matter [6]. The idea of the fourth state of matter results from the possibility that phase changes happen by dynamically giving energy to the matter, for example, the one from the solid state to fluid up to the gas state. A further phase progress might be thought as the one from the gas state to plasma state, regardless of whether these states is come to step by step by giving increasingly vitality to the system. Plasma can be viewed as a specific ionized gas, which retains some one of kind features which recognize it from a (ideal) gas.

What is plasma?

Plasma is ionized gas that comprises of a substantial number of various species, for example, electrons, positive and negative particles, free radicals, and gas molecules, atoms in the ground or energized state and quanta of electromagnetic radiation (photons) [7]. It is viewed as the fourth states of matter on the planet. It tends to be produced in the expansive range of temperature and weight by methods for coupling vitality to gaseous medium. This vitality can be mechanical, thermal, atomic, radian or conveyed by an electric current. Cold atmospheric plasma is a novel non thermal food processing innovation that utilizes energetic, responsive gases to inactivate spoilage microorganisms on meats, poultry, natural products, and vegetables. This adaptable sanitizing technique utilizes power and a carrier gas, for example, air, oxygen, nitrogen, or helium; antimicrobial synthetic chemical agents are not required. The essential methods of activity are because of UV light and responsive chemical substance results of the cold plasma ionization process. A wide exhibit of cold plasma frameworks that work at atmospheric pressure or in low pressure treatment chambers are a work in progress.

How plasma is generated?

The most generally utilized strategy for creating and maintaining a low-temperature plasma for mechanical and specialized application is by applying an electric field to a neutral gas [12]. Any volume of a neutral gas dependably contains a couple of electrons and ions that are formed, for instance, as the aftereffect of the collaboration of radioactive radiation with the gas. These free charge carriers are accelerated by the electric field and new charged particles might be made when these charge carriers collide with molecules and atoms in the gas or with the surfaces of the cathodes. This leads to an avalanche of charged particles that is eventually balanced by charge carrier losses, so that steady-state plasma develops. Accelerated electrons collide with gas atoms to excite or ionise them. Ionisation of gas atoms releases more electrons; this cascaded reaction can generate a rich abundance of highly reactive chemical species which are capable of inactivating a wide range of microorganisms including food borne pathogens and spoilage organisms.

Cold Plasma Technology in Foods:

Cold Plasma Technology in food industries depends on a gas release innovation a viable, practical, naturally safe technique for basic cleaning. The Vacuum Ultraviolet (VUV) energy is successful in the breaking most natural bonds (i.e. C-H, C-C, C=C, C-O and C-N) of surface contaminants this breaks separated high atomic weight contaminants. A second cleaning activity is done by the oxygen species made in the plasma (O2+, O2-, O3, O, O+, O-, ionized ozone, energized oxygen, and free electrons). These species respond with natural contaminants to frame H2O, CO, CO2, and lower atomic hydrocarbons. The subsequent surface is ultra clean/disinfected. The plasma initiated atoms and particles cause atomic 'sandblasting' and can separate natural organic contaminants.

Main Applications of Plasma Technology:

1) Disinfection of packaging materials:

Cold Plasma can be utilized to inactivate vegetative micro organisms and spores on food material packages. Particularly for temperature delicate items, this can have an clear advantage compared to heat treatments. What's more, plasma can likewise decrease the quantity of water utilized for cleansing of packaging materials. As cold plasma is a gas, the packaging material with irregular shape are effectively treated.

2) Disinfection of Food products:

At the point when microorganisms are situated at the surface of the food commodities cold plasma can be utilized for inactivation of both vegetative cells and spores. As the treatment is done at low temperature, the consequences for food quality and appearance of the item are negligible.

Applications of atmospheric cold plasma

The processing and operating cost of the cold plasma technology is very low due to that it plays an important role in the many applications. The different applications of these technology in various areas are: food and nutrition industry, medical and clinical [8], materials processing, material analysis, surface modification. ACP technology applies on various material which having distinct advantages for decontamination of foods [9]. ACP is increasingly under research for decontamination of fresh produce fruits and vegetables [10]. ACP technology majorly used to treat a variety of vegetables: fresh tomatoes, cherry tomatoes, lettuce, carrots, cucumbers and broccoli. The tomatoes and the lettuce were easier to decontaminate than the carrots, probably because of the surface structure. The technology is also used to treat various fruits and spices such as strawberries, apples, melons and mangos pears, spice e.g. red pepper, nuts. To inactivate the surface flora of the fresh meat and poultry and meat products, e.g. bacon, ham and ready to eat meat) and cheese the ACP technology is used. ACP is useful to control the microorganisms in the cereal industry because it doesn't generate too much heat which means it may damage food nutrition less. Recently, some scientists show that ACP is suitable for inactivation of the enzymes from fruit or vegetable origin [11]. ACP is a powerful tool for surface decontamination of not only foods but also food packaging materials (plastic bottles, lids and films) without adversely affecting their bulk properties, and does not result in any liquid effluents (residues). As the spices having antimicrobial activity ACP technology in combined with the essential oil (e.g. clove oil) to decontaminate the cellulose-based food packaging and to inactivate the surface microorganisms [12].

Advantages of Atmospheric Plasma :

1) Atmospheric cold plasma is zero moisture process.

2) It is suitable method for a food manufacturing condition.

3) Energy requirement for the processing is very less.

4) Reversion of a Reactive gas species after treatment.

5) Time requirement is very less.

6) It is emerging ultra-fast sterilization technique used for preservation.(sterilization takes only few minutes)

7) It is surface acting treatment so there is no effects on nutritional values.

8) The Process is suitable for thermo labile commodities operates at ambient temperatures.

9) It is a sterilisation method which inactivates all kinds of pathogens.

10) Capital cost is very low.

11) There is use of natural gases including nitrogen, argon, air, hydrogen and oxygen so it is Environmentally friendly technology[13].

Future Scope

It is observed that the Cold plasma technology is used for sterilization and inactivation of the surface of the of packaging polymers purpose. Cold plasma is used in the preservation of the food commodities so there there is a huge application in food processing. The amount of energy consumptions and stability depends up on the type of discharges used for treatment. Based on this parameters for the application of plasma should be optimized for maximum efficiency at low cost of operation. Many researchers successfully applied plasma on foods (solids and liquids) for the microbial inactivation but they did not explain its effects on the nutritional qualities and toxicology of treated foods. There is a necessary that application of plasma on foods should be recognized as GRAS after intense study and research (in vitro and in vivo) in this field. Future studies should be done on applications of plasma on food surfaces to change its physical and chemical properties with cost effective and to increase the shelf life of the food products.

References:

[1] Research Inventy: International Journal of Engineering And Science Vol.6, Issue 2 (February 2016), PP -15-20.

[2] J.R. Roth, S. Nourgostar, T.A. Bonds, IEEE Trans. Plasma Sci. 35, 233 (2007)

[3] Stoica M., Bahrim G., Cârâc, G. (2011) Factors that Influence the Electric Field Effects on Fungal Cells. In: Méndez-Vilas A. (ed.): Science against microbial pathogens: communicating current research and technological advances, 291 -302. Formatex Research Center, Badajoz.

[4] Afshari R., Hosseini H. (2014) Non-thermal plasma as a new food preservation method, Its present and future prospect, Journal of Paramedical Sciences, 5 (1),2008-4978.

[5] Bárdos L., Baránková H. (2010) Cold atmospheric plasma: Sources, processes, and applications, Thin Solid Films, 518, 6705–6713.

[6]Shakila Banu M., Sasikala P., Dhanapal A., Kavitha V., Yazhini G., Rajamani L. (2012) Cold plasma as a novel food processing technology, International Journal of Emerging trends in Engineering and Development, 4 (2), 803-818.

[7] Rossi F, Kylian O, Hasiwa M. Decontamination of surfaces by low pressure plasma discharges. Plasma Processes and Polymers. 2006; 3: 431 -442.

[8] Terrier O., Essere B., Yver M., Barthélémy M., Bouscambert-Duchamp M., Kurtz P., VanMechelen D., Morfin F, Billaud G., Ferraris O., Lina B., RosaCalatrava M., Moules V. (2009) Cold oxygen plasma technology efficiency against different airborne respiratory viruses, Journal of Clinical Virology, 45 (2), 119–124

[9] Misra N.N., Keener K.M., Bourke P., Mosnier J.P., Cullen P.J. (2014a). In-package atmospheric pressure cold plasma treatment of cherry tomatoes, Journal of Bioscience and Bioengineering, xx (1 -6), http://dx.doi.org/10.1016/j.jbiosc.2014.02.005.

[10] Kabir Jahid I., Han N., Ha S.D. (2014) Inactivation kinetics of cold oxygen plasma depend on incubation conditions of Aeromonas hydrophila biofilm on lettuce, Food Research International, 55, 181 – 189.

[11] Pankaj S.K., Bueno-Ferrer C., Misra N.N., Milosavljevi V., O'Donnell C.P., Bourke P., Keener K.M., Cullen P.J. (2014) Applications of cold plasma technology in food packaging, Trends in Food Science & Technology, 35 (1), 5-17

[12]Matan N., Nisoa M., Matan N., Aewsiri T. (2014) Effect of cold atmospheric plasma on antifungal activities of clove oil and eugenol against molds on areca palm (Areca catechu) leaf sheath, International Biodeterioration & Biodegradation, 86 (Part C), 196-201

[13] H Conrads and M Schmidt, Plasma generation and plasma Sources, 441 454. UK PII, (2000).