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Food-Drug Processing Through Cold Plasma Technology

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Abstract

Cold plasma is a new technology which is originated from the natural phenomenon named tundra. This technology has been used for electronics devices and printing technology before using in agriculture field. It has now been researching for the vast biological area due to its effects on microorganisms, chemical compounds' of food staffs, rheological aspects, nutrition values and organoleptic characteristics of plant and animal foods. So, several application of cold plasma in industry will be shown as a new area of consideration such as medical, wastewater treatment, and polymer technology and food science.

Gas ionization process which forms other reactive chemical materials like radicals, UV light and heat, show specific effect on the process object.

Plant products such as pharmaceutical plants are also a new area of scientific investigation subjects for cold plasma applications. Cold plasma in atmospheric pressure has been recorded that it can stabilize nitrogen in plants and soil. Therefore it has an important role in the fortification of plants components. Plasma-induced activation of Phyto-actuators in plants also has been recorded by plant physiology experts.

The aim of this article is to review the effects of cold plasma and it will be discussed on plant components from the view of their quality and quantities. Besides its technological aspect in the pharmacological field will be explained such as active components and functional food which are important in industry.

Key words: cold plasma, plant processing, health, pharmaceutical

1- Introduction

Partially ionized gas which acts on microbial viability, enzyme activity with minimum effect on biological tissues in the low temperature can be resulted via cold plasma technology (Šimončicová et al. 2019). Gas ionization process also forms other reactive chemical materials like radicals, UV light and heat which show specific effect on the process object (Vukić et al. 2017). Advances in technology causes practical applications for plasma which has been now be generated at atmospheric pressures (Misra et al. 2019).

Cold plasma has diverse application in many areas. The various application of cold plasma is shown in figure 1 (Brandenburg et al. 2018).

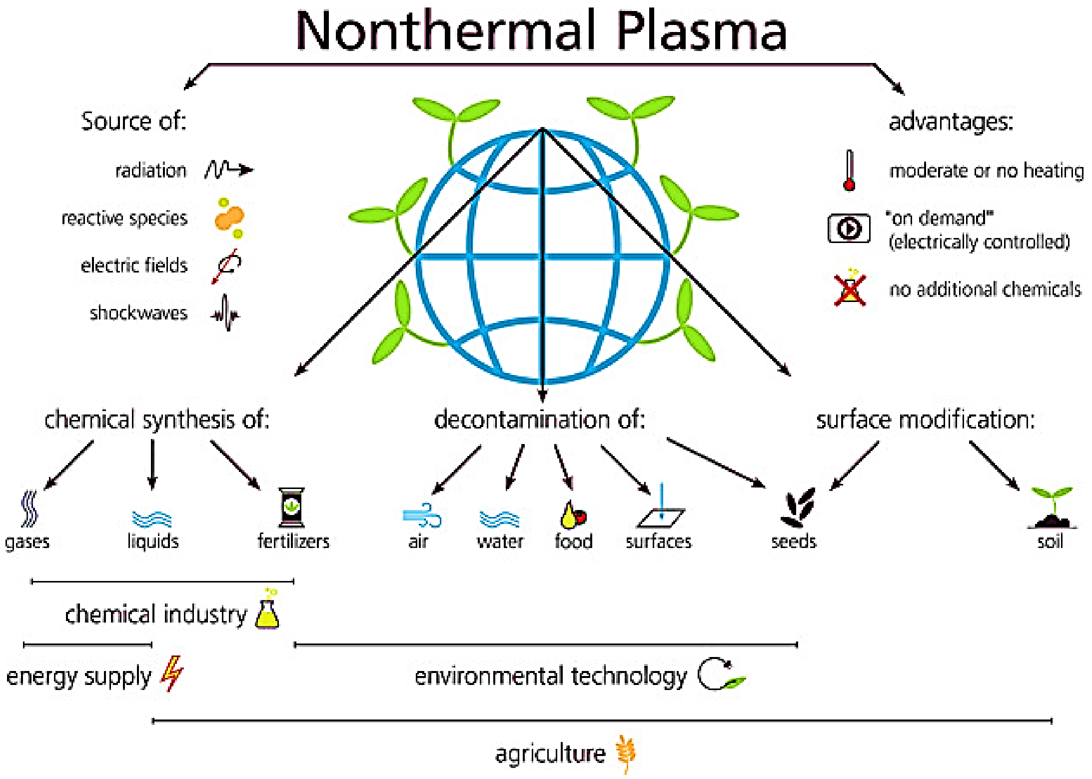


Figure 1- Several application of cold plasma in industry (Brandenburg et al. 2018)

Other applications has been recognized by Gavahian and Mousavi Khaneghah in 2019 (figure 2).

Figure 2- Other applications of cold plasma (Gavahian and Mousavi Khaneghah. 2019).

2- Literature review

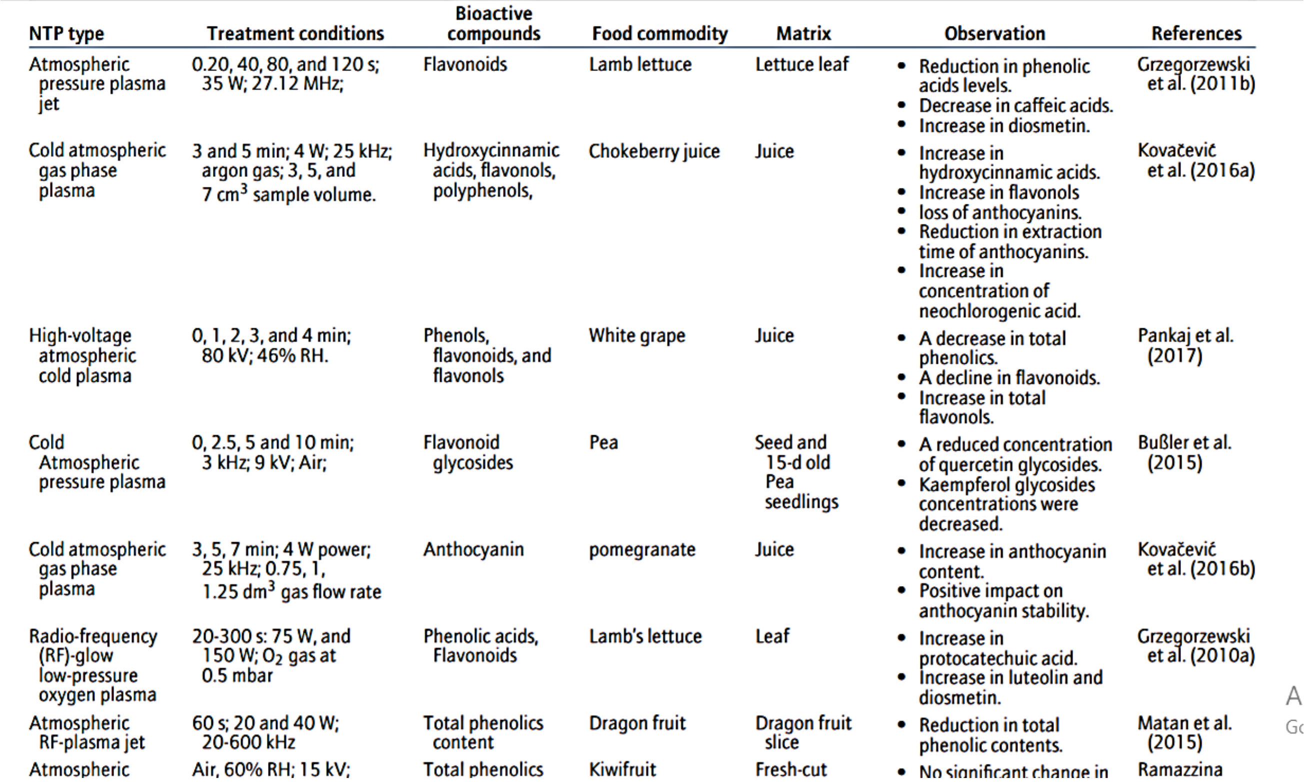
Many agricultural technologies, biological science, medical treatment or plant and food preservations can be optimized via cold atmospheric pressure plasma (CAPP) (Šimončicová et al. 2019). Degradation of many kinds of pesticides such as parathion and allergens such as tropomyosin, has been occurred via interaction between reactive species and UV generated by cold plasma (Gavahian and Mousavi Khaneghah. 2019).

Time and voltage of cold plasma have a positive effect on decreasing the microbial population and dielectric barrier discharge (DBD) does not change Physical properties of plant product such as cherry tomatoes for 2.5 min at 100 kV, and stored for 10 days (Misra et al. 2019).

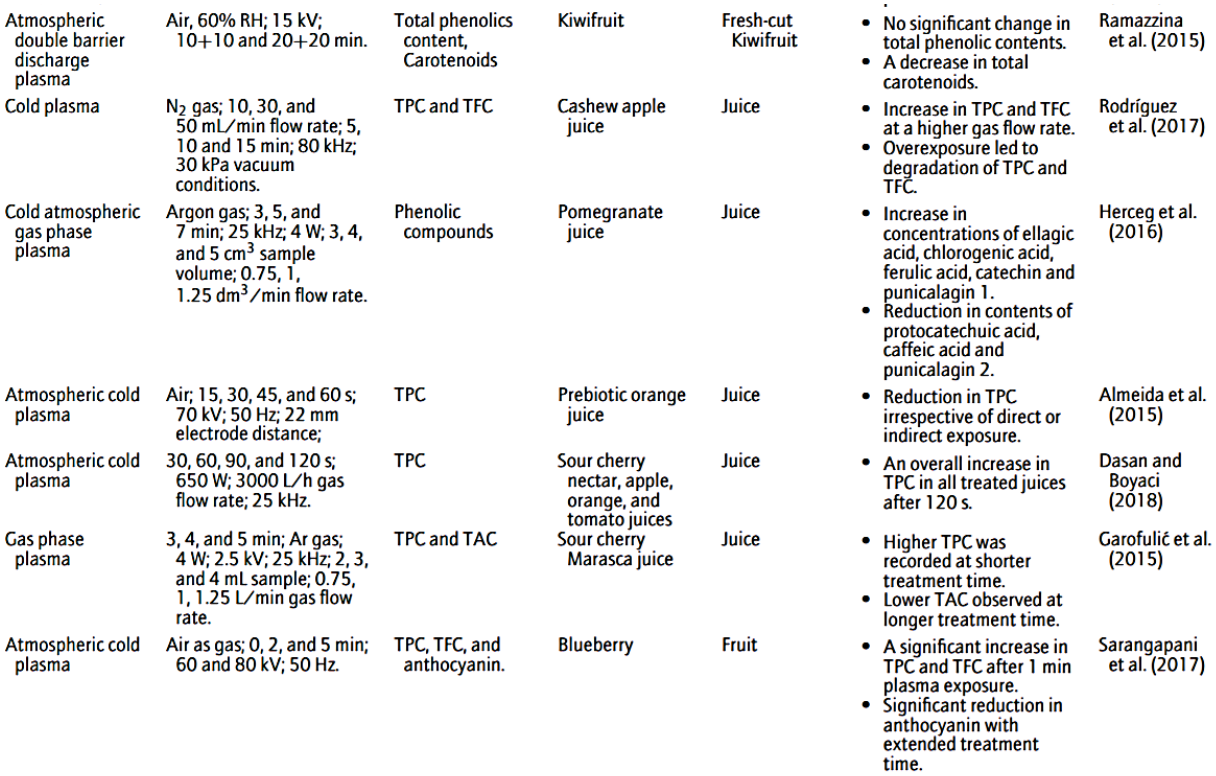
Of particular concern are emerging pharmaceutical contaminants which can be detoxified by cold plasma (Brandenburg et al. 2018). Treatment of surface areas has found its valuable application known as micro plasma geometries (Šimončicová 2019).

Effect of non-thermal plasma technology (NTP) treatment on the functional components of food has been summarized in table 1 with the concern of bioactive compounds changes by some technologies (Muhammad Aliyu et al. 2018).

Table1- Some application of cold plasma in functional components (Muhammad Aliyu et al. 2018)



NTP type	Treatment conditions	Bioactive compounds	Food commodity	Matrix	Observation	References
Atmospheric pressure plasma jet	0.20, 40, 80, and 120 s; 35 W; 27.12 MHz;	Flavonoids	Lamb lettuce	Lettuce leaf	• Reduction in phenolic acids levels. • Decrease in caffeic acids. • Increase in diosmetin.	Grzegorzewski et al. (2011b)
Cold atmospheric gas phase plasma	3 and 5 min; 4 W; 25 kHz; argon gas; 3, 5, and 7 cm^3 sample volume.	Hydroxycinnamic acids, flavonols, polyphenols,	Chokeberry juice	Juice	• Increase in hydroxycinnamic acids. • Increase in flavonols • loss of anthocyanins. • Reduction in extraction time of anthocyanins. • Increase in concentration of neochlorogenic acid.	Kovačević et al. (2016a)
High-voltage atmospheric cold plasma	0, 1, 2, 3, and 4 min; 80 kV; 46% RH.	Phenols, flavonoids, and flavonols	White grape	Juice	• A decrease in total phenolics. • A decline in flavonoids. • Increase in total flavonols.	Pankaj et al. (2017)
Cold Atmospheric pressure plasma	0, 2.5, 5 and 10 min; 3 kHz; 9 kV; Air;	Flavonoid glycosides	Pea	Seed and 15-d old Pea seedlings	• A reduced concentration of quercetin glycosides. • Kaempferol glycosides concentrations were decreased.	Bußler et al. (2015)
Cold atmospheric gas phase plasma	3, 5, 7 min; 4 W power; 25 kHz; 0.75, 1, 1.25 dm^3 gas flow rate	Anthocyanin	pomegranate	Juice	• Increase in anthocyanin content. • Positive impact on anthocyanin stability.	Kovačević et al. (2016b)
Radio-frequency (RF)-glow low-pressure oxygen plasma	20-300 s: 75 W, and 150 W; O_2 gas at 0.5 mbar	Phenolic acids, Flavonoids	Lamb's lettuce	Leaf	• Increase in protocatechuic acid. • Increase in luteolin and diosmetin.	Grzegorzewski et al. (2010a)
Atmospheric RF-plasma jet	60 s; 20 and 40 W; 20-600 kHz	Total phenolics content	Dragon fruit	Dragon fruit slice	• Reduction in total phenolic contents.	Matan et al. (2015)
Atmospheric	Air, 60% RH; 15 kV;	Total phenolics	Kiwifruit	Fresh-cut	• No significant change in	Ramazzina



Atmospheric double barrier discharge plasma	Air, 60% RH; 15 kV; 10+10 and 20+20 min.	Total phenolics content, Carotenoids	Kiwifruit	Fresh-cut Kiwifruit	• No significant change in total phenolic contents. • A decrease in total carotenoids.	Ramazzina et al. (2015)
Cold plasma	N_2 gas; 10, 30, and 50 mL/min flow rate; 5, 10 and 15 min; 80 kHz; 30 kPa vacuum conditions.	TPC and TFC	Cashew apple juice	Juice	• Increase in TPC and TFC at a higher gas flow rate. • Overexposure led to degradation of TPC and TFC.	Rodríguez et al. (2017)
Cold atmospheric gas phase plasma	Argon gas; 3, 5, and 7 min; 25 kHz; 4 W; 3, 4, and 5 cm^3 sample volume; 0.75, 1, 1.25 dm^3/min flow rate.	Phenolic compounds	Pomegranate juice	Juice	• Increase in concentrations of ellagic acid, chlorogenic acid, ferulic acid, catechin and punicalagin 1. • Reduction in contents of protocatechuic acid, caffeic acid and punicalagin 2.	Herceg et al. (2016)
Atmospheric cold plasma	Air; 15, 30, 45, and 60 s; 70 kV; 50 Hz; 22 mm electrode distance;	TPC	Prebiotic orange juice	Juice	• Reduction in TPC irrespective of direct or indirect exposure.	Almeida et al. (2015)
Atmospheric cold plasma	30, 60, 90, and 120 s; 650 W; 3000 L/h gas flow rate; 25 kHz.	TPC	Sour cherry nectar, apple, orange, and tomato juices	Juice	• An overall increase in TPC in all treated juices after 120 s.	Dasan and Boyaci (2018)
Gas phase plasma	3, 4, and 5 min; Ar gas; 4 W; 2.5 kV; 25 kHz; 2, 3, and 4 mL sample; 0.75, 1, 1.25 L/min gas flow rate.	TPC and TAC	Sour cherry Marasca juice	Juice	• Higher TPC was recorded at shorter treatment time. • Lower TAC observed at longer treatment time.	Garofulić et al. (2015)
Atmospheric cold plasma	Air as gas; 0, 2, and 5 min; 60 and 80 kV; 50 Hz.	TPC, TFC, and anthocyanin.	Blueberry	Fruit	• A significant increase in TPC and TFC after 1 min plasma exposure. • Significant reduction in anthocyanin with extended treatment time.	Sarangapani et al. (2017)

Cold Plasma has been used in microbial and viral inactivation, treatment of various skin diseases, wound healing, blood coagulation, teeth whitening, and antitumor therapy without significant impact on normal cells (Bekeschus et al. 2018). Inactivation of juice microbial spoilage while maintaining physicochemical properties in tomato juice - cold Atmospheric pressure Plasma (CAP) was utilized in Starek et al study (Starek et al.2019). PH and Dry matter content were not significantly affected by CAP technology but Small increase of lycopene and slight loss of vitamin C content were recorded (Starek et al.2019).

The effects of plasma treatment on wheat seed germination and seedling growth has been done by Los et al in 2019 although the reason of this phenomenon has been yet clear (Los et al in 2019).

3- Effect of cold plasma technology application on Bioactive Compounds

Bioactive compounds such as Polyphenols that are mostly derived from plants; consist of flavones, flavonols, flavan-3-ols, isoflavones, anthocyanidins, lignans, and so on.

Anthocyanin are phenolic flavonoids located in the cell vacuole which disrupts of its cell membrane by cold plasma and its inner substances such as polyphenols are being released and can be consumed more simply by human, resulting in a healthy body (Aliyu Idris et al. 2018).

Low-molecular-weight biomolecules such as antimicrobial peptides (bacteriocins) with the vast antimicrobial potency against fungi, bacteria, yeasts, virus, and cancer cells, are placed naturally in living organisms with a varying number of amino acids (Zhang & Gallo, 2016) which can bind to the lipid and phospholipid components on microbial cell wall, which cause decomposition of the lipid bilayer and therefore kill them (Muhammad Aliyu et al. 2018).

4- Conclusion

Cold atmospheric plasma treatment is a new non-thermal technology for food pharmaceutical components processing. There are several researches on the effectiveness of cold plasma in inactivation of foodborne and human pathogens on various alive or non-alive materials and surfaces. The effects of cold plasma have been proved on plant components from the view of their quality and quantities. However, scares studies have done on Bioactive Compounds and functional materials subjected on cold plasma. So, the future attempts can be directed on these areas which are important for human health.

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