ISPC 24

24TH INTERNATIONAL SYMPOSIUM ON PLASMA CHEMISTRY

NAPLES (ITALY) JUNE 9-14, 2019

Final Program

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

www.ispc24.com

Application of atmospheric pressure plasma for processing of selected materials

J. Pawlat[1], A. Starek[2], M. Kwiatkowski[1], P. Terebun[1],
A. Przekora[3], B. Chudzik[4], G. Ginalska[3], Z. Machala[5], M. Janda[5], K. Hensel[5]

[1]*Lublin University of Technology, Lublin, Poland*
[2]*University of Life Sciences in Lublin, Lublin, Poland*
[3]*Medical University of Lublin, Lublin, Poland*
[4]*Maria Curie-Skłodowska University, Lublin, Poland*
[5]*Comenius University, Bratislava, Slovakia*

Abstract: GlidArc reactor was used for inactivation of juice background spoilage microorganisms, as well as high count of inoculated yeast while maintaining physicochemical properties in tomato juice. Dry matter content and pH were not significantly influenced by atmospheric pressure plasma generated in GlidArc reactor. Small increase of lycopene, and slight loss of vitamin C content were observed. GlidArc was also applied for to evaluate the effect of plasma treatment on wettability and surface chemical composition of chitosan/β-1,3-glucan/HA biomaterial.

Keywords: atmospheric pressure plasma, GlidArc reactor, biological material

1. Introduction

Cold atmospheric pressure plasma generated in GlidArc (GAD) reactor [1-3] can contain biochemically active ingredients like charged particles (ions and electrons), free radicals and reactive oxygen and nitrogen species (RONS), etc. of bactericidal, fungicidal and stimulatory properties. Non thermal plasma can be a flexible and potential tool for processing of different types of biological and abiotic materials, thus it can be used for decontamination of food, especially fruit and vegetable juices and in biotechnology for customizing material properties.

Tomato (*Solanum lycopersicum L.*), is one of the most important vegetable crops in the world, contains a great variety of biologically active substances and is consumed as processed products such as tomato juice, ketchup, sauce, paste, and canned tomatoes. Thermal processing is the most common method applied in the food industry to extend the shelf life of juice by inactivating microorganisms and enzymes. Pankaj et al. [4] reported no significant change in pH, acidity and electrical conductivity of the white grape juice after CAP treatment. Xu et al. [5] showed that 120-s CAP treatment did not cause a significant Brix or pH change, but reduced vitamin C by 22%, compared to 50% for heat pasteurization.

Chitosan/curdlan/HA is nontoxic, implantable, osteoconductive biomaterial, which promotes osteoblast growth and proliferation as well as increases bone alkaline phosphatase level thereby enhancing cell differentiation [6].

This work reports experimental results on the plasma treatment's impact on the quality and physicochemical properties of the fresh tomato juice and its effectiveness in inactivation of the background microflora and high counts of the spoilage yeasts. Effects of short-time GAD treatment on surface properties of chitosan/β-1,3-glucan/HA biomaterial are summarized.

2. Experimental apparatus, materials and methods

2 electrodes AC powered GlidArc reactor of mean power ranging 40 W operated with air and nitrogen substrate gases. The experimental set-up is presented in Fig. 1. Temperature, measured using uninsulated K-type thermocouple with electronic temperature compensation multimeter was below 30^{o}C for all experimental settings.

Fresh tomatoes (*Lycopersicon Esculentum cv. Apis F1*) were purchased from a local fruit market, Lublin, Poland. Juice was extracted using a slow juice extractor and divided into five 5 ml samples. The nozzle was placed 1 cm from the surface of the juice, which had undergone plasma treatment. Treatment time ranged 30, 60, 120, and 300 seconds. Samples were analyzed for background microflora, including the total aerobic mesophilic viable count and the total yeast and mold count. The pH of the tomato juice samples was measured using a digital pH meter, total carotenoid and lycopene content were determined by spectrophotometer and content of vitamin C (L-ascorbic acid) was determined using Tillmans dye.

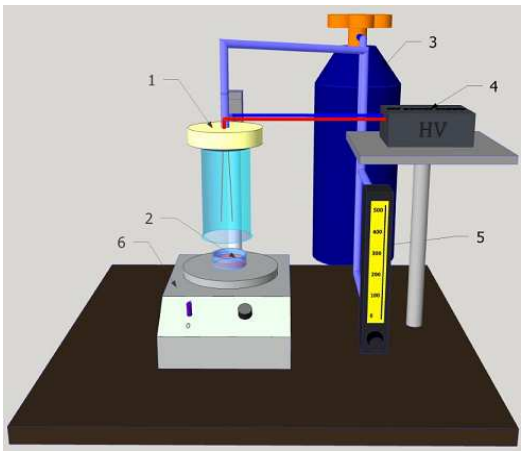

Fig. 1. Schematic diagram of the atmospheric plasma treatment system (1- GAD, 2- sample, 3- gas supply, 4- power supply, 5- flowmeter, 6- magnetic stirrer).

The chitosan/β-1,3-glucan/HA biomaterial was produced by mixing the liquid phase (the blend of 2.0 wt.% chitosan and 8.0 wt.% β-1,3-glucan) with 80 wt.% HA granules followed by thermal gelation for 20 min. at 90ºC and neutralization in NaOH solution [6] and treated for 16s by nitrogen plasma generated in GAD reactor. Static and dynamic water contact angles (CA) were observed and ATR-FTIR analysis was performed to determine changes in surface chemical composition of the biomaterial.

3. Results

The reduction of the number of microorganisms is fresh juice by more than 3 log, which is satisfactory from the point of view of juice decontamination, was obtained after 5 min. of plasma treatment: 3.45-log CFU/ml reduction for the total aerobic mesophilic bacteria colonies (Fig. 2), 3.55-log CFU/ml reduction for yeast, and 3.32-log CFU/ml reduction for molds were achieved. In the case of yeast and mold, almost complete eradication of the colony forming units was obtained after 5 minutes of plasma treatment. There was also an advantageous effect of reduction in the total number of microorganisms on the following days of storing the plasma-treated juice at 4°C.

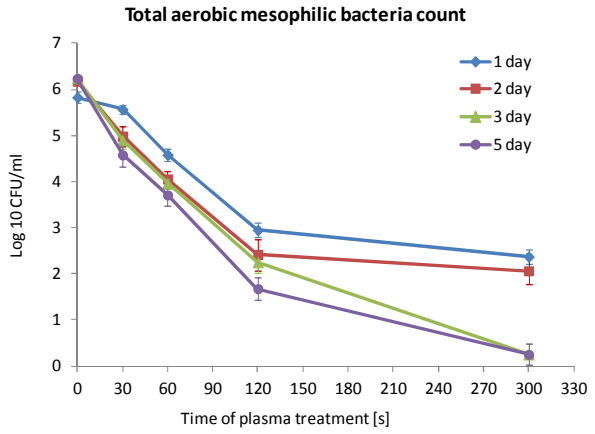

Fig. 2. Total aerobic mesophilic bacteria count of un-pasteurized tomato juice treated with non-thermal atmospheric pressure plasma (air) for 0, 30, 60, 120, and 300 s and stored at +4°C for 1-5 days.

There was no significant difference in pH of the juice samples. The increase in the total carotenoid and lycopene content was 13% and 11%, respectively. The content of vitamin C in the control sample of tomato juice was 274.0 mg/100 g d.w. and 300-second processing with GAD caused 5% loss at maximum.

Observation of advancing water CA revealed slightly different surface behaviour of plasma treated sample in comparison to the control: decrease to 20^{o} after time and then its further penetration to the pores (Fig. 3). No significant changes in functional groups composition on the surface of the biomaterial was observed after 16 s of GAD treatment in nitrogen.

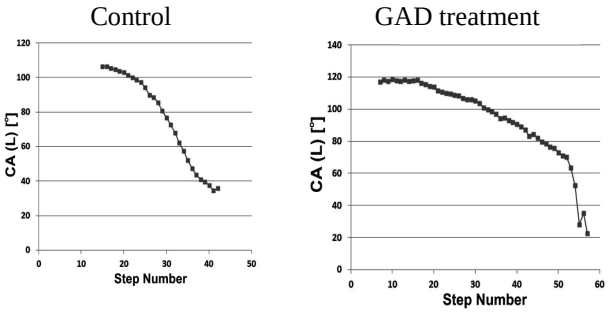

Fig. 3. Dynamic measurement of water contact angle for GAD treatment.

4. Conclusions

The time of exposure was the main factor influencing the tomato juice treatment efficacy with low temperature plasma generated from air as a substrate gas.

5 minutes of plasma treatment enabled 3.45-log CFU/ml, 3.55-log CFU/ml and 3.32-log CFU/ml reductions just after the treatment for the total aerobic mesophilic bacteria colonies, yeast and molds, respectively. However, statistically significant reduction was obtained already after 30 s of the plasma treatment for the total viable count and after 60 s for the yeast and mold count.

Obtained data demonstrated that plasma treatment of chitosan/β-1,3-glucan/HA biomaterial with the use of nitrogen as a substrate gas only slightly affects wettability and does not change surface chemical composition of the tested composite material.

Acknowledgement

This work was supported by NCN M-Era-net PNANO4BONE, Polish-Slovak Bilateral Cooperation Programme (PlasmaBioAgro) PPN/BIL/2018/1/00065 and SK-PL-18-0090, Miniatura I Project 2017/01/X/NZ9/00477, LUT Inkubator Innowacyjności+ and CEEPUS CIII-AT-0063.

5. References

[1] J. Pawlat, A. Starek A. Sujak, M. Kwiatkowski, P. Terebun, M. Budzeń, Plasma Processes and Polymers **15**, 1700064 (2018).

[2] BG Dasan, B Onal-Ulusoy, J Pawlat, J Diatczyk, Y Sen, M Mutlu, Food Bioprocess Technol **10**, 650–661 (2017).

[3] J.-L. Brisset, J. Pawlat, Plasma Chem Plasma Process **36**, 355–381 (2016).

[4] S. Pankaj, Z. Wan, W. Colonna, K. Keener, Journal of the Science of Food and Agriculture **97**, 4016–4021 (2017).

[5] L. Xu, A. Garner, B. Tao, K. Keener, Food Bioprocess Technol **10**, 1778–1791 (2017)

[6] A. Przekora, K. Pałka, G. Ginalska, J. Biotech. **182,** 46-53 (2014)