Application of Non-Thermal Plasma in Food Treatment and Biological Material Conditioning

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In this study, a novel approach was employed to evaluate the quality of selected food and biomaterial products using cold atmospheric plasma. Research covered multiple food matrices, including a carrot-banana smoothie, fresh bovine milk, tomato juice, gluten-free and wheat-rye bread, etc.

A gliding arc discharge (GAD) (Fig.1) system using air and nitrogen gases effectively reduced microbial contamination without compromising nutritional quality.

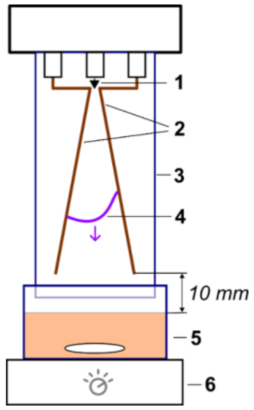

Fig. 1. Gliding arc system: 1 – forced gas flow; 2 – electrodes; 3 – glass tube; 4 – gliding arc; 5 – open container with juice and stirrer bar ; 6 – magnetic stirrer [1].

Plasma-treated milk preserved up to 89% of B-group vitamins, significantly outperforming traditional processing methods. Toxicological assessments indicated improved zebrafish survival rates, demonstrating the safety of CAP-treated milk.

CAP treatment (300 s) of tomato juice significantly reduced total microbial counts and extended the juice's shelf life to 10 days while preserving physicochemical properties such as pH, Brix, lycopene, and vitamin C (up to ~11% of lycopene content increase was observed). Microscopy revealed that CAP treatment preserved cell structure in NFC tomato juice, exhibiting only minor chromoplast alterations even after 600 s. Cold atmospheric plasma generated by a gliding-arc reactor significantly reduced microbial loads—total aerobic bacteria, yeasts, and molds—by about 3 $\log_{10}$ after 300 s of treatment, with further microbial declines during refrigerated storage [2]. After 600 s of treatment, microbial contamination was reduced to below quantifiable limits.

GAD reactor used for treatment of freshly pressed carrot juice (10–30 min exposure) yielded stable microbial quality, maintaining low counts of aerobic bacteria, yeasts, and molds over 3 days at 6 °C. Enhancement in colloidal stability and zeta potential were observed. Carotenoids (e.g., β-carotene), and polyphenols content was increased in comparison to untreated samples. Microscopy revealed improved homogenization and minor tissue disruption, aiding release of bioactive compounds. From the consumer's perception point of view, slight reductions in brightness (L*) and chromaticity (a*, b*), indicating modest and acceptable color shifts was noticed [1].

A synergistic combination of sumac spice and CAP treatment was tested for the first time to preserve carrot-banana smoothie, demonstrating enhanced mineral, sugar, vitamin C, and polyphenol content. However, toxicological studies using zebrafish larvae revealed that sumac at high concentrations exhibited significant toxicity due to its low pH, leading to 100% mortality at a 1:5 dilution.

Plasma treatment effectively eliminated yeast, mold, and mesophilic bacteria, improving microbiological quality of bread. While beneficial in reducing moisture content, an increase in hardness was noted due to the drying effect of gas flow, particularly in gluten-free bread [3].

Cold atmospheric plasma as non-thermal food preservation method enhances food safety, extends shelf life, and maintains or improves nutritional properties, however, it requires target optimization. The findings suggest CAP as a viable alternative to traditional processing techniques.

References

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