The impact of plasma treatment using the GlidArc generator on apple juice in a stationary and flow system

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The consumption of fruit juices worldwide shows a constant upward trend, especially for juices without preservatives and other additives. This is due to increased consumer awareness, who pay attention to flavor qualities (lack of unpleasant aroma and artificial colors) and the positive impact on health. As a result, they are willing to pay more for fresh and more natural juices than for thermally processed juices with chemical preservatives. Numerous scientific studies confirm that fruit juices are a great source of important nutrients for the human body thanks to bioactive compounds such as carotenoids, polyphenols, phenols, anthocyanins, and phytochemicals. Moreover, consuming such juices prevents chronic diseases such as cancer and cardiovascular diseases. Therefore, it is extremely important to preserve as many valuable compounds and nutrients as possible during juice processing and treatment [1-8].

Currently, pasteurization based on thermal processing technologies is used to ensure the appropriate level of microbiological safety and enzyme inactivation. Unfortunately, these procedures can cause changes in the quality of juices, which is not acceptable to potential consumers. Various attempts are made to minimize the negative effects and preserve the sensory, nutritional, and functional properties of juices. Countless efforts are being made to replace current pasteurization methods with innovative non-thermal processing technologies [1], [9].

As it is widely known, during plasma treatment of various juices, certain general tendencies can be observed. However, the action of CAP (Cold Atmospheric Plasma) may vary depending on the plasma source used or the treatment parameters. Also, juice properties, including the type of fruits used to make the juice, may affect the obtained research results. A thorough understanding of CAP application for treating different juices is important for optimizing processing parameters to achieve microbiologically safe juices of high quality [1].

The aim of the study was to develop a cold plasma treatment system to improve the microbiological safety of juices while preserving their basic physicochemical values. The research material was freshly squeezed apple juice, which was subjected to plasma treatment using a Glid Arc reactor with air as the working gas, in both stationary and flow systems.

Studies have shown that regardless of the type of plasma treatment system used (stationary, flow and flow with attachment), the number of microorganisms considered decreased with the extension of treatment duration. The overall number of microorganisms in the control juice (not subjected to plasma treatment) was 4.60 log10 cfu/ml, whereas according to the current requirements set forth in the 2005 Codex Standards, it should not exceed 4 log10 cfu/ml. Treating samples in the stationary system helped reduce the number of aerobic bacteria and obtain a product suitable for consumption that met the applicable criteria. The number of colonies ranged from 3.00 log10 cfu/ml (after 30 minutes of treatment) to 3.44 log10 cfu/ml (after 5 minutes of treatment). Meanwhile, the amount of yeast and mold in the same samples ranged from 2.59 log10 cfu/ml to 3.32 log10 cfu/ml, whereas in the control sample, the number of these microorganisms was at a moderate level of 3.34 log10 cfu/ml.

Flow-through plasma treatment with an attachment demonstrated the highest effectiveness in eliminating microorganisms present in apple juice. It was observed that in the control sample, the total number of microorganisms exceeded (by 1.79 log10 cfu/ml) the amount indicating the suitability of the juice for consumption. A 5-minute treatment was still insufficient in lowering this value, whereas extending the treatment duration to 15 and 30 minutes resulted in obtaining juice that met the required criteria. The overall number of microorganisms in these juice samples was 3.49 log10 cfu/ml and 3.22 log10 cfu/ml, respectively. Analyzing the results of yeast and mold counts also revealed the decontaminating effect of the applied treatment on the number of colonies grown. In the juice not subjected to plasma treatment, the number of colony-forming units was 3.47 log10 cfu/ml, while after 5, 15, and 30 minutes of this treatment, it decreased to 3.34 log10 cfu/ml, 3.17 log10 cfu/ml, and 2.55 log10 cfu/ml, respectively.

It was observed that plasma-treated juices (in most cases) showed slightly lower brightness (a decrease in parameter L*) compared to control products. Furthermore, fruit products included in the research program were more red (an increase in parameter a*) when subjected to plasma treatment in flow systems than their respective control samples. Conversely, the stationary treatment system (S) lasting 15 and 30 minutes resulted in a decrease in the examined chromaticity coefficient compared to products not treated with cold plasma. The parameter b*, indicating the yellowing of juices depending on the duration of all applied treatment systems, was at similar or lower levels compared to control beverage samples.

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