SUMMARY

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Fumigation of Kamchatka berry and Japanese haskap plants with gaseous ozone as an alternative method of protecting plants against fungal diseases and improving the quality of the fruit and extending their storage time

The aim of this doctoral dissertation, presented as a series of thematically related articles, was to evaluate the effectiveness of gaseous ozone fumigation as an alternative method of plant protection against fungal diseases in selected varieties of haskap (*Lonicera caerulea* var. *kamtschatica*) and Japanese haskap (*Lonicera caerulea* var. *emphyllocalyx)* between 2021 and 2024. Selected plant physiological indicators, which are markers of their health, were assessed. Additionally, the impact of the proposed method on the mechanical and biological properties of the fruit immediately after harvest and during storage was determined, with particular emphasis on improving quality and extending their postharvest shelf life. An important element of the work was also to present the potential of *in vitro* micropropagation in the production of Japanese haskap (*Lonicera caerulea* var. *emphyllocalyx*) explants.

The first stage of the study was to determine the effect of the applied doses of gaseous ozone on selected plant physiological traits, which are indicators of plant condition and health, particularly in terms of fungal diseases. The study described in publication 1 included analysis of the OJIP induction curve (Fv/Fm, Mo, PI total), analysis of ChlM, FlvM, and AnthM content, and the NFI index, as well as analysis of selected leaf gas exchange parameters (E, Ci, Gs). The obtained results showed that the use of ozone did not significantly affect the variation in most of the analyzed physiological parameters of the tested *Lonicera caerulea* var. *kamtschatica* and Lonicera caerulea var. *emphyllocalyx* cultivars. Significant differences in the mean values of physiological traits and gas exchange indices of plants compared to the control group occurred only with the highest ozone dose (5 ppm for 5 minutes). The mean Pitotal value decreased significantly after the application of gaseous ozone at a dose of 5 ppm for 5 minutes in the case of *Lonicera caerulea* var. *emphyllocalyx* for the '139-24' clone and the Lori cultivar in 2022, compared to the control sample. At the same time, a significant reduction in the E index value was noted for the same ozone dose in plants of the '21-17' clone of *Lonicera caerulea* var. *emphyllocalyx* in all years of the experiment, compared to the control sample. Based on the obtained test results and measurements, it was concluded that the proposed doses of gaseous ozone in the process of plant fumigation for protection against fungal pathogens did not cause a phytotoxic effect. The best results in plant condition and health, determined by chlorophyll fluorescence and gas exchange 10 indices, were recorded for *Lonicera caerulea* var.

kamtschatica and *Lonicera caerulea* var. *emphyllocalyx* treated with ozone gas at a concentration of 5 ppm for 1 and 3 min.

The next stage of the study involved determining the effect of gaseous ozone fumigation on the biological properties of the studied varieties and clones of *Lonicera caerulea* var. *kamtschatica* and *Lonicera caerulea* var. *emphyllocalyx* (publication 2). The effect of the proposed gaseous ozone doses on the vitamin C content, total phenolic compound content, and antioxidant potential of the studied fruits was determined. Furthermore, the effect of gaseous ozone fumigation on selected morphological parameters of the harvested fruits was assessed. The results obtained during the study revealed differences in the content of selected bioactive compounds in the fruits of the studied *Lonicera caerulea* L. subspecies. However, these differences depended on the growing season, variety or clone, and the gaseous ozone doses tested during the plant fumigation process. It was found that the tested gaseous ozone doses significantly influenced the total phenolic compound content and antioxidant potential of the studied fruits. At the same time, it was shown that the best results were achieved for fruit collected from plants treated with gaseous ozone at a dose of 5 ppm for 3 minutes. The total phenolic compound content for the tested fruits of this experimental variant increased by 11,5%, compared to the content recorded for the control sample. After the application of ozone at a dose of 5 ppm for 5 min, an increase in the antioxidant potential of FRAP and ABTS was noted by 6.7% and 6.1%, respectively, compared to the potential of the fruit from the control sample. Based on the obtained research results, it was concluded that the use of appropriately selected doses of gaseous ozone in the fumigation process of *Lonicera caerulea* L. plants can shape the biological value of the produced fruit.

The next research step was to determine the suitability of ozonation of *Lonicera caerulea* L. plants for extending the storage life of harvested fruit. To this end, the effect of proposed ozone gas doses on selected morphological and mechanical properties of *Lonicera caerulea* var. *kamtschatica* and *Lonicera caerulea* var. *emphyllocalyx* was determined (publication 3). Uniaxial puncture resistance of the fruit skin and flesh was measured as an indicator of fruit durability throughout the supply chain, including during storage. The study determined that the fruits of the studied Japanese haskap cultivars and clones were characterized by greater resistance to puncture of the skin and flesh compared to haskap, which determines their improved resistance to harvesting, transport, and potential storage. However, it should be noted that the observed values of destructive 11 force within a given subspecies varied depending on the cultivar and clone. The tested doses of gaseous ozone during the fumigation of the studied plants affected the mechanical parameters of the fruit. However, this effect varied depending on the duration of the treatment. value of the produced fruitThe best resistance to mechanical damage was demonstrated by *Lonicera caeurlea* L. fruits fumigated with gaseous ozone at a concentration of 5 ppm for 3 minutes. Based on the obtained results, it can be concluded that applying an appropriate dose of ozone can contribute to the production of fruit with improved mechanical properties, which directly translates into improved storage stability. Furthermore, the use of machine learning to design accurate models enabled a more accurate

interpretation of the obtained results regarding the assessment of fruit resistance to mechanical damage. The tested machine learning algorithms also provided accurate models for predicting deformation and energy consumption until puncture. These models can be used in practice to design storage processes for *Lonicera caerulea* var. *kamtschatica* and *Lonicera caerulea* var. *emphyllocalyx* fruits produced using gaseous ozone during the fumigation process.

One of the research stages was to determine the potential for micropropagation of Japanese haskap, a method previously unused in horticultural practice. Publication 4 presents result on the effects of selected plant fragments, growth substances (IBA, BA, mT), and low temperature (4°C) on the growth and development of newly created planting material during micropropagation. Based on the experimental results, it was demonstrated that significantly more ST explants than NF explants began visible growth in the proliferation phase. The use of BA growth substance at a concentration of 1 mg · dm−3 resulted in significantly better plant health and improved proliferation of the cultures compared to the control plants (micropropagation without the addition of growth substance). Furthermore, the use of low temperature during the acclimation phase of new plants significantly affected their survival. However, this effect varied depending on the variety and clone. The best results were obtained with *in vitro* cultures of the clone 139-24.

Keywords: *Lonicera caerulea* L., fruit, fumigation, gaseous ozone, bioactive and mechanical properties, plant physiological parameters, machine learning, *in vitro*