Chemical composition of edible polish Basidiomycota treated with essential oils fumigation

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Edible mushrooms play an important role in Polish culinary tradition and, at the same time, constitute valuable food material, and are a source of protein, dietary fibre, minerals, and bioactive compounds with antioxidant properties. Wild-growing species, such as king bolete (Boletus edulis) and bay bolete (Imleria badia), are particularly important, as they are highly valued for their unique sensory attributes. At the same time, mushroom fruiting bodies are among the most perishable food materials. Their high water content, soft tissue structure, intensive postharvest metabolism, and susceptibility to mechanical damage, dehydration, browning, and microbial growth cause cause rapid quality deterioration within a short storage period. For this reason, the search for mild techniques limiting the postharvest degradation of mushrooms without changing their character as a fresh product is an important issue in food technology. One such method may be fumigation with essential oils, which involves exposing the product to essential oil constituents without direct contact between the liquid substance and the surface of the fruiting bodies. Previous studies on this technique have focused mainly on fruits, vegetables, and selected cultivated mushrooms, whereas wild-growing mushrooms have remained poorly described. Moreover, there has been a lack of comprehensive studies covering not only visible quality attributes, but also nutrient composition, the profile of bioactive compounds, and the biological activity.

The aim of this doctoral dissertation was to evaluate the effect of fumigation with selected essential oils on postharvest quality, chemical composition, the content of bioactive compounds, and selected biological properties of edible Basidiomycota mushrooms. The study included three species: button mushroom (Agaricus bisporus), used as a model species, and two wild-growing species, B. edulis and I. badia. This dissertation included four stages of investigation: a literature review on essential oil fumigation, the selection of essential oils and their concentrations based on the analysis of mushroom quality parameters, studies on changes in nutrient components, and the evaluation of antioxidant properties and the biological activity of extracts in in vitro models.

In the first stage of the study, a screening assessment of eight essential oils applied at seven doses was carried out. The effectiveness of the variants was evaluated using a multi-criteria approach, taking into account cumulative changes in parameters such as weight loss, colour change, browning, cap opening, and visible symptoms of spoilage. The analyses made it possible to select two most favourable variants: fumigation with fennel and spruce essential oils at a dose of 65 µL per 3 L container. The selected variants were then applied to three mushroom species stored for 96 hours under non-refrigerated conditions. The obtained results showed that essential oil fumigation may limit selected undesirable postharvest changes, including weight loss, the development of spoilage symptoms, and some colour changes. However, this effect was not universal and depended on the mushroom species, the type of essential oil, and the parameter assessed. Fumigation also modified the profile of volatile organic compounds in mushrooms, affecting both compounds characteristic of the natural mushroom aroma and leading to the presence of small amounts of essential oil-derived constituents in the fruiting bodies.

In the part concerning chemical composition, it was shown that fumigation limited the degradation of some nutrients, including selected sugars and polyols, fatty acids, and vitamins. However, not all analysed compounds were protected to the same extent, and for some of them the effect was weak, inconsistent, or species-dependent. In studies on bioactive compounds, better retention of selected carotenoids and phenolic compounds, a lower level of lipid peroxidation, and favourable changes in the activity of enzymes associated with browning and phenolic metabolism were observed in fumigated samples. The evaluation of mushroom extracts in HT-29, RAW 264.7, and SH-SY5Y cell models showed that the chemical changes occurring in mushrooms under the influence of fumigation were only partially reflected in their biological activity in vitro. The most visible effects concerned selected oxidative stress markers in HT-29 cells and the reduction of nitric oxide production in RAW 264.7 cells treated with extracts from fumigated mushrooms. However, a clear and strong cytoprotective or anti-inflammatory effect was not confirmed in all applied models.

The conducted studies demonstrated that essential oil fumigation may be a promising, but selective and species-dependent method supporting the short-term storage of fresh edible mushrooms. The most important achievement of the study was showing that essential oil fumigation may affect fresh edible mushrooms at multiple levels – not only by limiting selected symptoms of postharvest degradation, but also by modulating retention of nutrients, bioactive compounds, and oxidative stress markers. Thus, the study indicated that the effectiveness of postharvest treatments applied to fresh mushrooms should not be assessed only on the basis of appearance or commercial shelf life, but also with reference to the stability of their chemical composition and potential biological properties. An important aspect of the study was the extension of the research to wild-growing species, which, despite their high culinary value, seasonal availability, and importance in local trade, have remained poorly recognised in terms of the possibilities of extending their shelf life. The obtained results also showed that fennel and spruce essential oils may exhibit partially complementary modes of action, which justifies further research into their application.