BAB V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this work, it is shown that freshness deterioration in fresh fruits and vegetables can be considered as a process consisting of integrated physiological reactions, metabolic phenomena, and membrane lipids alteration in postharvest storage. Contrary to conventional physiological and physicochemical criteria of quality evaluation, freshness deterioration is characterized as an integral biological phenomenon taking place in several directions.

The first aim was reached through the investigation of the physiological responses of tomato fruits under conditions of low-temperature storage in terms of respiration rate, color development, and ion leakage. Low-temperature storage inhibits respiratory activity and delays the color development in tomato fruits; however, the ion leakage demonstrates a considerable numerical increase when kept at 2 °C for a long time. Nevertheless, no statistically significant differences were found in ion leakage in respect of different combinations of storage time and temperature. Thus, ion leakage, color development, and respiration should be considered as different physiological indicators, and none of them could be considered as a single criterion for freshness deterioration.

The second objective was realized by investigating metabolic changes related to deterioration of mango freshness during storage. There was continuous decrease of citric acid but an accumulation of sucrose during the process of storage whereas there was a relatively minor change in the concentration of glucose and fructose. Such metabolisms demonstrated changes related to ripening and deterioration progression, indicating that metabolomics analysis is able to give some intermediate level of information between the physiological characteristics of quality and molecular processes occurring during postharvest storage of food.

The third objective three was realized by lipidomic analysis of fresh cut cabbage during storage. Out of 1,308 transitions monitored in MRM mode, 133 lipid species were putatively annotated and later characterized with the use of multivariate statistics. Membrane lipid remodelling occurs simultaneously with the physiological deterioration such as CO_2 generation, colour changes, microbial growth and sensory quality deterioration. Also, with the use of Partial Least Squares Regression, there was strong relationship established between lipids profile and cumulative CO_2 generation, indicating

that membrane lipid remodeling is accompanied with freshness deterioration and senescence progression.

This goal was accomplished through the identification of five TAG molecular species; TAG 52:5_FA16:1, TAG 52:4_FA16:0, TAG 54:7_FA18:3, TAG 52:4_FA18:1 and TAG 52:6_FA16:0. The TAG molecular species were found to have high associations with CO2 production and thus served as the most informative predictors in the lipidomic predictive model for freshness deterioration. Comparison with the prior study of lipidomic profiling on whole cabbage revealed that whereas there was difference in the level of abundance of the TAG in both intact and fresh-cut tissues, the TAG continued to be the lipid class most correlated with freshness deterioration. This shows that membrane lipid dynamics are highly dependent on the integrity of the tissue during post-harvest storage.

In summary, this dissertation work presents an integrative approach to the study of freshness deterioration based on the interplay of physiological, metabolic, and molecular responses. Through the use of the tomato fruit, mango fruit, and fresh-cut cabbage as biological models of interest, it has been shown that freshness deterioration is not fully characterized by a single physiological or physicochemical parameter. The lipidomic analysis of the fresh-cut cabbage further shows the possibility of the use of membrane lipid dynamics as molecular parameters of freshness deterioration and reveals particular TAG species as molecular markers for freshness deterioration. It must be noted at this point that these lipid species are only to be regarded as molecular markers in the case of fresh-cut cabbages but cannot be generalized to any other fresh produce systems. However, the discovery of particular lipid species related to physiological freshness response may serve as a starting point to further explore this approach as a means of developing molecular freshness-related indicators for diverse fresh produce systems.

5.2 Recommendations

On the basis of the results generated by this dissertation, future studies need to be conducted to validate the five identified candidate TAG markers using various types of horticultural produce, cultivars, physiological conditions, and storage environments to check the validity and broad application possibilities of these candidate markers in assessing the freshness of produce. Furthermore, future studies should confirm the structural identity and quantify the identified lipid species using authentic standards and appropriate analytical methods. This will increase the validity of the candidate markers and

clarify if the identified TAG markers are specific to different commodities or a general response of lipids related to freshness deterioration.

The validation of the identified TAG markers for various fresh produce commodities, storage conditions, and datasets is an important step towards the development of molecular markers based on lipids for assessing the freshness of horticultural produce. In future, studies must integrate the molecular information along with physiological properties, metabolite profiling, and non-destructive sensors to develop more comprehensive freshness assessment models.

However, the application of markers based on the use of TAGs requires further validation using independent sample sets and a variety of storage conditions, as well as evaluation of robustness, reproducibility, cost-effectiveness, and adaptability to fast and non-invasive measurement techniques. The immediate significance of the current work therefore is the selection of candidate biomarkers and the establishment of a molecular basis, while the development of a system of freshness evaluation is one of the perspectives for future research.