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A comparison of the metabolic effect of short-term cold stress on leaves and fruit of two contrasting strawberry genotypes

Weinert, Christoph H.[1]; Kanbar, Adnan[2]; Egert, Björn[1]; Trierweiler, Bernd[1]; Daumann, Joachim[2]; Kulling, Sabine E.[1]; Nick, Peter[2]*

[1]Max Rubner-Institut, Department of Safety and Quality of Fruit and Vegetables, Karlsruhe.

[2]Karlsruhe Institute of Technology, Botanical Institute, Department Molecular Cell Biology.

*E-Mail: christoph.weinert@mri.bund.de

Study background: Cold stress is an unfavourable but realistic condition in agricul-tural practice. Cold stress occurs in the temperate zone but is as well relevant in desert areas where temperatures usually drop strongly at night. Against the back-ground of a growing world population, the pressure to grow crops also in arid regions is increasing. For example, strawberry cultivation in Egypt during the winter months helps to supply the important market in the gulf states but sudden cold snaps may threaten harvest. Therefore, cultivars with improved cold tolerance are needed. In this study, we compared the metabolic reaction of two wild-type strawberry geno-types to cold stress.

Methods: Strawberry genotypes G69 (cold-resistant) and G51 (cold-sensitive) from the National Gene Bank for German Crop Wild Relative Species (WEL) were grown outdoors in pots in the Botanical Garden Karlsruhe in spring 2020. 10 plants were allocated each to the treatment and the control group. During the harvest season, mature fruits were harvested batch-wise and exposed to 2°C for 6 h in a cooling chamber. At the end of the growing season, whole plants of the treatment groups received the same cold treatment in the dark. Immediately after the treatment, leaves and fruit were shock-frozen in liquid nitrogen, lyophilized, and ground in a ball mill. After extraction with methanol, evaporation and derivatisation, an untargeted GC(×GC)-MS metabolomics analysis was performed.

Results: 829 and 519 analyte features were detected in the leaf and fruit samples, respectively. In case of the leaves, the most striking and consistent reaction to cold stress was the expected accumulation of maltose. Apart from that, the leaf metabolite profile of the cold-resistant genotype G69 was not much affected. In contrast, strong metabolic shifts were recorded in the leaves of G51: Cold stress led to higher levels of most amino acids and many sugars (except glucose, fructose and sucrose) as well as several inositols, organic acids, fatty acids, and phytosterols while concentrations of, e.g., catechins and other phenols were significantly lower. Compared to the leaves, the effect of cold shock on fruit was much more uniform but the metabolic reaction was more pronounced with G69. Pipecolic, pyruvic, cinnamic and beta-hydroxybutyric acid as well as tryptophan, cysteine, epicatechin and several sugars/sugar-like compounds were elevated while several amino acids and organic acids were found at in part considerably lower levels.

In this study, concerning the leaves, we could show that the genotype G69 has not only a cold-resistant phenotype but is also metabolically more robust against cold stress - an interesting trait in view of breeding programmes. Further, harvested fruit may also react metabolically to short-term cold stress which can affect overall fruit quality and thus consumer acceptance.