Summary

Many flower bulbs have a life cycle of a year or more, flowering either in spring or in summer. Nevertheless, year-round production of cut flowers has become common practice in horticulture. To control flowering, which is necessary for the year-round production of flowers, bulbs are exposed to specific temperature regimes to affect their growth and development. When storage or planting conditions are not properly chosen, physiological disorders in bulb development may occur. Flower bud abortion and aberrant leaves are examples of such physiological disorders. Disorders in the bulbs are usually not visible externally. They become apparent after planting even though they are often induced during storage.

The aim of this study was to gain a better insight in the processes underlying physiological disorders in flower bulbs, induced by improper storage conditions. Changes in the water status are expected to be often involved in the development of the induced aberrations. The water status of stored flower bulbs was therefore assessed using both magnetic resonance imaging (MRI, known from the medical applications) as well as classical water status measurements. It was assessed whether the obtained parameters might serve as 'early indicators' of an impaired flower bulb quality and thus as indicators for the internal quality of stored bulbs. This might lead to a tool to detect the presence of disorders at an early stage of development. Such an application could avoid further cost of storage and planting of impaired bulbs and potentially increases the chances to minimize the damage. Furthermore, it would enable optimization of storage conditions of new flower bulb genera more easily. In addition, flower quality can be better guaranteed.

In this research the mechanism underlying several physiological disorders in flower bulbs was studied by exposing the bulbs to sub-optimal storage conditions to induce the aberrations.

The development of the disorder 'bud abortion' in tulip was studied by exposing the bulbs to long-term cold and dry storage. Bud abortion then manifests after planting in a short, unopened flower bud with white, papery tepals. Bud abortion was emerging after 23 weeks of storage and subsequent planting. When storage was continued, the shoot became fully aborted. The aberration resulted from the combined effects of storage and planting conditions. With the use of MRI, water concentration values and T_1 and T_2 relaxation times were determined non-invasively. T_1 and T_2 are indicative of the mobility of water molecules. Whereas T_1 is mainly influenced by the composition of the tissue sap, T_2 is also influenced by the anatomical structure of the tissue in question. The T_1 and T_2 relaxation times of the stamens, the *in vivo* determined water concentration of the shoot and the classically determined water content and osmolality of the scale and shoot tissue changed gradually throughout storage. These changes probably indicate a decreasing availability of water for root and shoot growth directly after planting, implying an increased risk of bud abortion. Planting at lower temperatures might enable the bulb to overcome its water deficiency by water uptake from the soil and enable the bulb to flower properly. This seems not longer possible in fully aborted bulbs. These bulbs do not seem to be able to initiate root or shoot elongation and water is probably withdrawn from the bud for growth of the daughter bulbs. This withdrawal of water from the shoot was first detectable in the stamens. The water content, water potential and *in vivo* water concentration in the stamens dramatically dropped. Degenerated parenchyma cells were observed in the stamens.

Apart from long-term cold storage, bud abortion in tulip can also be induced by storing bulbs at high temperatures. Application of a high-temperature treatment to abort the flower is used in practice to propagate the planting stock. To study whether the course of processes accompanying bud abortion is always similar, bud abortion was also induced by storage at high temperatures. A subsequent period of low temperatures was applied to fulfill the cold requirement of the bulbs. With increasing storage temperature and duration, flower quality shifted from normal flowers, to flowers with shriveled tepals and eventually to stems without a flower. The ion-leakage from the shoots of stored bulbs increased as well with the duration of the high-temperature pretreatment and seems therefore indicative of a decreased flower quality. After the cold requirement was fulfilled aberrations in the flowers could be visualized non-invasively with the use of T_2-weighted MRI. In contrast to long-term cold storage, storage at high temperatures did not affect the water status of the bulbs. Since the underlying processes appear to be different, more specific definitions than the general term 'bud abortion' could and should be used to indicate the apparently different physiological disorders.

For the year-round production of lily flowers, bulbs are stored for long periods at subzero temperatures. The start of the freezing period and the freezing temperature should be chosen properly to minimize the risk of freezing injury. Because of the variability in optimal storage conditions between cultivars and years, freezing injury cannot be entirely prevented. The effects of freezing injury in lily bulbs were therefore assessed. Prolonged storage at too low temperatures resulted in freezing damage, manifesting with aberrant leaves and eventually aborted shoots. The decreased water potential and water content show that freezing damage involves dehydration of the damaged tissue. The decreased T_1 relaxation times in the stem and shoot apex of freezing damaged bulbs, determined non-invasively by MRI, also points towards desiccation of the tissue. Changes in the ion-leakage from the shoot during storage at too low temperatures, probably indicating changes in membrane permeability, coincided with the increased damage found after planting the bulbs. Changes in the ion-leakage of the scales and in the osmolality of the scales and shoot are probably indicative of an acclimation of the tissue to the applied storage temperatures.

Based on a preliminary study on severely damaged (water-soaked) lily bulbs it can be concluded additionally that water content, water potential and T_1 (and T_2) relaxation times can be used to distinguish different kinds of damage in lily bulbs.

The possibilities of MRI to assess non-invasively the internal quality of flower bulbs appear extensive. T_2-weighted imaging appeared to be a suitable application to visualize morphological changes like the growth of the shoot and the development of daughter bulbs. Aberrant developments of the floral parts in tulip bulbs after storage at high temperatures and the presence of aborted buds in *Hippeastrum* (amaryllis) bulbs could well be observed. Water concentration and T_1 and T_2 relaxation times were successfully used to assess the water status in the bulbs and to monitor water status related disorders like bud abortion in tulips after long-term cold and dry storage, freezing injury and water-soaking in lily bulbs.

Thus, MRI has a great potential for the evaluation of the internal quality of flower bulbs and horticultural products in general. However, currently the technique is still too expensive for routine, high-throughput applications, but on-line applications will become more feasible in the future.