

Table of Contents

Summary.....1

Summary in German.....3

Abbreviations.....5

**1 Literature Review ..... 8**

1.1 Importance of Starch..... 8

1.2 Starch Composition – Amylose and Amylopectin..... 8

1.3 Amylopectin Structure .....11

1.4 From Chains to the Crystalline Starch Granule..... 12

1.5 Diversity of Starch Granules ..... 13

1.6 ADP-glucose Synthesis - the Committed Step of Starch Biosynthesis..... 15

1.7 Amylose Synthesis..... 15

1.8 Amylopectin Synthesis ..... 16

1.9 Synthesis of  $\alpha$ -1, 4 Linked Linear Glucans – Soluble Starch Synthases ..... 17

1.9.1 Starch Synthase 1 – Synthesis of External, Short Chains..... 17

1.9.2 Starch Synthase 2 – Synthesis of External or Internal, Intermediate Chains . 17

1.9.3 Starch Synthase 3 – Synthesis of Spanning, Long Chains..... 18

1.9.4 Starch Synthase 4 – Formation of Starch Granules ..... 19

1.10 Generation of  $\alpha$ - 1, 6 Linked Branching Points – Starch Branching Enzymes.. 20

1.10.1 *In vitro* Analyses of Different Type BE..... 20

1.10.2 Genetic Analyses of Different Type BE ..... 21

1.10.3 Heterologous Expression of Different Type BE ..... 22

1.11 Removal of  $\alpha$ -1,6-Branched by Starch Debranching Enzymes ..... 22

1.11.1 Enzyme Specificities of ISA and LDA in Starch Synthesis and Starch Degradation..... 22

1.11.2 Functions of Different ISA Complexes in Amylopectin Synthesis ..... 23

1.12 Formation of Starch Granules ..... 24

1.12.1 Synthesis of Primers for Granule Initiation ..... 24

1.12.2 Possible Enzymes Involved in Primer Synthesis and Granule Formation ..... 25

1.12.3 Controls of Granule Morphology ..... 26

1.13 Aim ..... 27

|          |  |            |
|----------|--|------------|
| <b>2</b> | <b>Genetic Evidence That Chain Length and Branch Point Distributions Are Linked Determinants of Starch Granule Formation in Arabidopsis .....</b>  | <b>29</b>  |
| <b>3</b> | <b>Molecular Genetic Analysis of Glucan Branching Enzymes from Plants and Bacteria in Arabidopsis Reveals Marked Differences in Their Functions and Capacity to Mediate Starch Granule Formation .....</b> | <b>60</b>  |
| <b>4</b> | <b>Starch Synthase 4 Is Essential for Coordination of Starch Granule Formation with Chloroplast Division during Arabidopsis Leaf Expansion .....</b>   | <b>87</b>  |
| <b>5</b> | <b>Characterization of N- and C-terminal Regions of SS4 in Determination of Starch Granule Formation in Arabidopsis Leaves .....</b>   | <b>117</b> |
| <b>6</b> | <b>General Discussion and Future Perspectives.....</b>   | <b>174</b> |
| 6.1      | Chain Lengths and Branching Point Distribution Determine Starch Formation .  | 175        |
| 6.1.1    | SS Isoforms Determine Chain Lengths and Influence Branching Patterns of Amylopectin .....  | 175        |
| 6.1.2    | Glucan Crystallization and ISA-mediated Degradation in Starch Synthesis  | 176        |
| 6.2      | Branching Enzyme – A Key Enzyme Activity Determines Branching Points and Influences the Final Structure of Amylopectin .....   | 178        |
| 6.2.1    | Different Type BE Determines Distinct Amylopectin Structure and Morphology.....  | 178        |
| 6.2.2    | Abundance of BE Influences Starch Content and Amylopectin Structure ...  | 180        |
| 6.2.3    | Other Effects in BE Transformed Lines and Further Investigation of Various Type BE .....   | 180        |
| 6.3      | Starch Granule Formation Requires SS4 .....  | 181        |
| 6.3.1    | SS4 Promotes Granule Formation and Determines Granule Morphology in Leaves   | 182        |
| 6.3.2    | Granule-Free Chloroplasts in <i>ss4</i> and in GS expressing lines .....   | 183        |
| 6.3.3    | Future Approaches for Understand the Mechanism of Granule Formation .  | 184        |
| <b>7</b> | <b>References .....</b>  | <b>186</b> |
| <b>8</b> | <b>Curriculum vitae.....</b>   | <b>196</b> |