

# Regulatory mechanisms of carotenoid biosynthesis in potato tubers

Stefania Pasare<sup>1,2</sup>, Peter M. Bramley<sup>2</sup>, Paul D. Fraser<sup>2</sup>, Alison Roberts<sup>1</sup> and Mark A. Taylor<sup>1</sup>

<sup>1</sup> SCRI, Invergowrie, Dundee, DD2 5DA, Scotland, UK

<sup>2</sup> Royal Holloway, University of London, Egham Hill, Egham, TW20 0EX



## Introduction

Isoprenoid biosynthetic pathways provide a wide-range of metabolites essential for plant development and storage organ food quality. Amongst them are carotenoids, photosynthetic pigments and important micronutrients with provitamin A activity. Globally, it was estimated that 140–250 million children under five years of age are affected by vitamin A deficiency, so understanding the regulation of isoprenoid metabolic networks is fundamental in producing foods with enhanced nutrient content.

Many isoprenoids are synthesized in the plastid, however in potato tubers there are gaps in our knowledge about how this biosynthesis is regulated. Previous transgenic work, whilst providing proof of principle that gene expression changes can bring about improvements (Shewmaker *et al.* 1999; Ducreux *et al.* 2005), have not helped us understand the different tiers of regulation that can be addressed to make further improvements in isoprenoid levels.

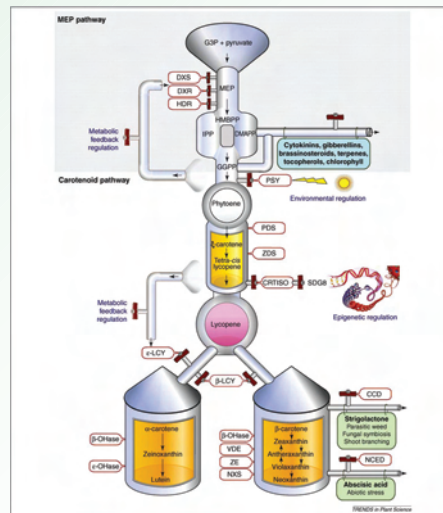


Figure 1. Major reactions in the higher plant carotenoid biosynthetic pathway showing enzymes, carotenoids and their precursors (pipes), carotenoid sink (barrel), carotenoid-derived signaling hormones (green signs) and other MEP isoprenoid-derived metabolites (blue sign). The windows displayed within the chrome pipes indicate abundant carotenoid pigments found in photosynthetic tissues and also represent key nodes for regulation in the pathway. Carotenoid biosynthesis is modulated by environmental factors (light), chromatin modification and metabolic feedback regulation. The side funnels represent examples of metabolic feedback control mechanisms acting upon biosynthetic gene expression as a result of altered PSY and CRTISO enzymatic activity, respectively. First, the bottleneck in phytoene biosynthesis is regulated by PSY and its overexpression increased DXS and DXR mRNA levels post-transcriptionally in etiolated tissues. Second, loss-of-function CRTISO mutants show reduced eLCY transcript levels in etiolated tissues. Abbreviations: bLCY, b-cyclase; bOHase, b-hydroxylase; CCD, carotenoid cleavage dioxygenase; CRTISO, carotenoid isomerase; DXR, 1-deoxy-D-xylulose 5-phosphate reductoisomerase; DXS, 1-deoxyxylulose-5-phosphate synthase; eLCY, e-cyclase; eOHase, e-hydroxylase; GPP, geranylgeranyl diphosphate; HDR, 1-hydroxy-2-methyl-2-(E)-butenyl 4-diphosphate reductase; NCE1, NCE2, NCE3, NCE4, NCE5, NCE6, NCE7, NCE8, NCE9, NCE10, NCE11, NCE12, NCE13, NCE14, NCE15, NCE16, NCE17, NCE18, NCE19, NCE20, NCE21, NCE22, NCE23, NCE24, NCE25, NCE26, NCE27, NCE28, NCE29, NCE30, NCE31, NCE32, NCE33, NCE34, NCE35, NCE36, NCE37, NCE38, NCE39, NCE40, NCE41, NCE42, NCE43, NCE44, NCE45, NCE46, NCE47, NCE48, NCE49, NCE50, NCE51, NCE52, NCE53, NCE54, NCE55, NCE56, NCE57, NCE58, NCE59, NCE60, NCE61, NCE62, NCE63, NCE64, NCE65, NCE66, NCE67, NCE68, NCE69, NCE70, NCE71, NCE72, NCE73, NCE74, NCE75, NCE76, NCE77, NCE78, NCE79, NCE80, NCE81, NCE82, NCE83, NCE84, NCE85, NCE86, NCE87, NCE88, NCE89, NCE90, NCE91, NCE92, NCE93, 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