



Universiteit  
Leiden  
The Netherlands

## Metabolic changes in *Arabidopsis thaliana* plants overexpressing chalcone synthase

Dao, T.H.H.

### Citation

Dao, T. H. H. (2010, February 18). *Metabolic changes in Arabidopsis thaliana plants overexpressing chalcone synthase*. Retrieved from <https://hdl.handle.net/1887/14755>

Version: Corrected Publisher's Version

[Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

License: <https://hdl.handle.net/1887/14755>

**Note:** To cite this publication please use the final published version (if applicable).

---

## References

---

- Abdel-Farid I.B., Kim H.K., Choi Y.H., Verpoorte R (2007). Metabolic characterization of *Brassica rapa* leaves by NMR spectroscopy. *J. Agric. Food Chem.* 55, 7936–7943.
- Ahmad M., Jarillo J.A., Smirnova O., Cashmore A.R. (1998) Cryptochrome blue-light photoreceptors of *Arabidopsis* implicated in phototropism. *Nature* 392, 720–723.
- Amedeo P., Habu Y., Afsar K., Scheid O. M., Paszkowski J. (2000) Disruption of the plant gene *MOM* releases transcriptional silencing of methylated genes. *Nature* 405, 203–206.
- An C., Ichinose Y., Yamada T., Tanaka Y., Shiraishi T., Oku H. (1993) Structure and organization of the genes encoding chalcone synthase in *Pisum sativum*. *Plant Mol. Biol.* 21, 789–803.
- Arakawa O. (1988) Photoregulation of anthocyanin synthesis in apple fruit under UV-B and red light. *Plant Cell Physiol.* 29, 1385–1390.
- Arias J.A., Dixon R.A., Lamb C.J. (1993) Dissection of the Functional Architecture of a Plant Defense Gene Promoter Using a Homologous in Vitro Transcription Initiation System. *Plant Cell* 5, 485–496.
- Askerlund P., Sommarin M. (1996) Calcium efflux transporters in higher plants. In M Smallwood, JP Knox, DJ Bowles, eds, *Membranes: Specialized Functions in Plants*. BIOS Scientific Publishers Ltd., Oxford, UK, 281–299.
- Baker S.M., White, E.E. (1996) A chalcone synthase/stilbene synthase DNA probe for conifers. *Theor. Appl. Genet.* 92, 827–831.
- Balandrin M.J. and Klocke J.A. (1988) Medicinal, aromatic and industrial materials from plants. In Y.P.S. Bajaj (ed.), *Biotechnology in Agriculture and Forestry. Medicinal and Aromatic Plant*, vol. 4. Springer-Verlag, Berlin, Heidelberg, pp. 1-36.

- Baum G., Long J.C., Jenkins G.I., Trewavas A.J. (1999) Stimulation of the blue light phototropic receptor NPH1 causes a transient increase in cytosolic Ca<sup>2+</sup>. Proc. Natl. Acad. Sci. USA 96, 13554-13559.
- Beggs C.J., Jehle A.S., Wellmann E. (1985) Isoflavonoid formation as an indicator of UV-stress in bean (*Phaseolus vulgaris* L.) leaves: the significance of photorepair in assessing potential damage by increased solar UV-B radiation. Plant Physiol. 79, 630-634.
- Bell A.A. (1981) Biochemical mechanisms of disease resistance. Annu. Rev. Plant Physiol. 32, 21-81.
- Bell J.N., Dixon R.A., Bailey J.A., Rowell P.M., Lamb C.J. (1984) Differential induction of chalcone synthase mRNA activity at the onset of phytoalexin accumulation in compatible and incompatible plant: pathogen interactions. Proc. Natl. Acad. Sci. USA 81, 3384-3388.
- Bell J.N., Ryder T.B., Wingate V.P.M., Bailey J.A., Lamb C.J. (1986) Differential accumulation of plant defense gene transcripts in a compatible and an incompatible plant: pathogen interaction. Mol. Cell Biol. 6, 1615-1623.
- Benhamou N., Belanger R. R., (1998) Benzothiadiazole-mediated induced resistance to *Fusarium oxysporum* f. sp. *radicis-lycopersici* in Tomato. Plant Physiol. 118, 1203-1212.
- Besseau S., Hoffmann L., Geoffroy P., Lapierre C., Pollet B., Legrand M. (2007) Flavonoid Accumulation in *Arabidopsis* Repressed in Lignin Synthesis Affects Auxin Transport and Plant Growth, Plant Cell 19, 148-162.
- Block A., Dangl J.L., Hahlbrock K., Schulze L.P. (1990) Functional borders, genetic fine structure, and distance requirements of cis elements mediating light responsiveness of the parsley chalcone synthase promoter. Proc. Natl. Acad. Sci. USA 87(14), 5387-5391.
- Bloor S.J., Abrahams S. (2002) The structure of the major anthocyanin in *Arabidopsis thaliana*. Phytochemistry 59, 343-346.
- Bohm B.A. (1998) Introduction to flavonoids, Vol. 2. Amsterdam, Netherlands: Hardwood Academic Publishers
- Bol J. F., Linthorst H. J. M., Cornelissen B. J. C. (1990) Plant pathogenesis-related proteins induced by virus infection, Annu. Rev. Phytopathol. 28, 113-138.

## References

---

- Bomati E.K., Austin M.B., Bowmann M.E., Dixon R.A., Noel J.P. (2005) Structural elucidation of chalcone reductase and implications for deoxychalcone biosynthesis. *J. Biol. Chem.* 280, 30496–30503.
- Bongue B.M.; Phillips D.A. (1995) Nitrogen stress regulates gene expression of enzymes on the flavonoid biosynthetic pathway of tomato *Plant Physiol. Biochem.* 33, 539– 546.
- Bosco D., Meda P., Iynedjian P.B. (2000) Glucokinase and glucokinase regulatory protein: mutual dependence for nuclear localization. *Biochem. J.* 348 , 215-222.
- Bowles D. (1990) Defense-related proteins in higher plants. *Annu. Rev. Biochem.* 59, 873–907.
- Brignolas F., Lacroix B., Lieutier F., Sauvard D., Drouet A., Claudot A.C., Yart A., Berryman A.A., Christiansen E. (1995) Induced responses in phenolic metabolism in two Norway spruce clones after wounding and inoculations with *Ophiostoma polonicum*, a bark beetle-associated fungus. *Plant Physiol.* 109, 821– 827.
- Brosché M., Strid A. (2003) Molecular events following perception of ultraviolet-B radiation by plants. *Physiol. Planta.* 117, 1-10.
- Brown D.E., Rashotte A.M., Murphy A.S., Tague B.W., Peer W.A., Taiz L., Muday G.K. (2001). Flavonoids act as negative regulators of auxin transport *in vivo* in *Arabidopsis thaliana*. *Plant Physiol.* 126, 524–535.
- Bruns B., Hahlbrock K., Schafer E. (1986). Fluence dependente of the ultraviolet-light-induced accumulation of chalcone synthase mRNA and effects of blue and far-red light in cultured parsley cells. *Planta* 169, 393-398.
- Buck N., Callaghan T.V. (1999) The direct and indirect effects of enhanced UV-B on the moth caterpillar *Epirrita autumnata*. *Ecol. Bull.* 47, 68-76.
- Buer C.S., Muday G.K. (2004) The *transparent testa4* mutation prevents flavonoid synthesis and alters auxin transport and the response of *Arabidopsis* roots to gravity and light. *Plant Cell* 16, 1191-1205.
- Buchholz G., Ehmann B., Wellmann E. (1995) Ultraviolet light inhibition of phytochromeinduced flavonoid biosynthesis and DNA photolyase formation in mustard cotyledons (*Sinapis alba* L.). *Plant Physiol.* 108, 227-234.

- Burbulis I.E., Winkel S.B. (1999) Interactions among enzymes of the *Arabidopsis* flavonoids biosynthesis pathway. Proc. Natl. Acad. Sci. USA 96, 12929-12934.
- Burbulis I.E., Iacobucci M., Shirley B.W. (1996) A null mutation in the first enzyme of flavonoid biosynthesis does not affect male fertility in *Arabidopsis*. Plant Cell 8, 1013-1025.
- Bush D.S. (1995) Calcium regulation in plant cells and its role in signaling. Annu. Rev. Plant Physiol. Plant Mol. Biol. 46, 95-122
- Cameron D.C., Altaras N.E., Hoffman M.L., Shaw, A.J. (1998) Metabolic engineering of propanediol pathways. Biotechnol. Prog. 14, 116-125.
- Campos A.D., Ferreira A.G., Hampe M.M.V., Antunes I.F., Branca N., Silvera E.P., Silva J.B., Osorio V.A. (2003) Induction of chalcone synthase and phenylalanine ammonia-lyase by salicylic acid and *Colletotrichum lindemuthianum* in common bean. Braz. J. Plant Physiol., 15(3), 129-134.
- Carrari F., Nunes N.A., Gibon Y., Lytovchenko A., Ehlers L. M., Fernie A.R. (2003) Reduced expression of aconitase results in an enhanced rate of photosynthesis and marked shifts in carbon partitioning in illuminated leaves of *Lycopersicon pennellii*. Plant Physiol. 133, 1322-1335
- Chappell J., Hahlbrock K. (1984) Transcription of plant defense genes in response to UV light or fungal elicitor. Nature 311, 76-78.
- Chet I. (1993) Biotechnology in plant disease control. Wiley-Liss, New York.
- Cheynier V. (2005) Polyphenols in foods are more complex than often thought. Am. J. Clin. Nutr. 81, 223S-229S.
- Choi Y.H., Kim H.K., Verpoorte R. (2006) Metabolomics, in : Kayser O., Quax W. (Eds), Medicinal Plant Biotechnology From Basic Research to Industrial Applications, Wiley-VCH, Weinheim, pp. 9-28.
- Choi Y.H., Tapias E.C., Kim H.K., Lefeber A.W.M., Erkelens C., Verhoeven J.T.J., Verhoeven, Brzin J., Zel J., Verpoorte R. (2004) Metabolic discrimination of *Catharanthus roseus* leaves infected by phytoplasma using  $^1\text{H}$ -NMR spectroscopy and multivariate data analysis. Plant Physiol. 135, 2398-2410.
- Choudary A.D., Lamb C.J., Dixon, R.A. (1990) Stress responses in alfalfa (*Medicago sativa* L.). VI. Differential responsiveness of chalcone synthase induction to

## References

---

- fungal elicitor or glutathionein electroporated protoplasts. Plant Physiol. 94, 1802–1807.
- Christensen A.B., Gregersen P.L., Olsen C.E., Collinge D.B. (1998a) A flavonoid 7-O-methyltransferase is expressed in barley leaves in response to pathogen attack. Plant Mol. Biol. 36, 219-227.
- Christensen A.B., Gregersen P.L., Schroder J., Collinge D.B. (1998b) A chalcone synthase with an unusual substrate preference is expressed in barley leaves in response to UV light and pathogen attack. Plant Mol. Biol. 37: 849–857.
- Christie J.M., Jenkins G.I. (1996) Distinct UVB and UV-A/Blue light signal transduction pathways induce chalcone synthase gene expression in *Arabidopsis* cells. Plant Cell 8, 1555–1567.
- Clark T.A., Zeyen R.J., Smith A.G., Carver T.L.W., Vance C.P. (1994) Phenylalanine ammonialyase mRNA accumulation, enzyme activity, and cytoplasmic responses in barley isolines, differing in *Ml-a* and *ml-o* loci attacked by *Erysiphe graminis* f. sp. *hordei*. Physiol. Mol. Plant Path. 44, 171-185.
- Clough S.J., Bent A.F., (1998) Floral dip: a simplified method for *Agrobacterium*-mediated transformation of *Arabidopsis thaliana*. Plant J.16 (6), 735-743.
- Creelman R.A., Mullet J.E. (1997) Biosynthesis and action of jasmonate in plants. Annu. Rev. Plant Physiol. Plant Mol. Biol. 48, 355–381.
- Creelman R.A., Tierney M.L., Mullet J.E. (1992) Jasmonic acid/methyl jasmonate accumulated in wounded soybean hypocotyls and modulate wound gene expression. Proc. Natl Acad. Sci. USA 89, 4938–4941.
- Cuadra P., Harborne J.B. (1996) Change in epicuticular flavonoids and photosynthetic pigment as a plant response to UV-radiation, Naturforsch. 51c, 671-680.
- Dalkin K., Edwards R., Edgington B., Dixon R.A. (1990) Stress responses in alfalfa (*Medicago sativa* L.). I. Induction of phenylpropanoid biosynthesis and hydrolytic enzymes in elicitor-treated cell suspension culture. Plant Physiol. 92, 440-446.
- Davies C.R., Wareing P.F. (1965) Auxin-directed transport of radiophosphorus in stems. Planta 65, 139–156.

- De Bruyne T., Pieters L., Deelstra H., Vlietinck A. (1999) Condensed vegetable tannins: biodiversity in structure and biological activities. *Biochem. Syst. Ecol.* 27, 445-459.
- De Buck S., Jacobs A., Van Montagu M., Depicker A. (1999) The DNA sequences of T-DNA junctions suggest that complex T-DNA loci are formed by a recombination process resembling T-DNA integration. *Plant J.* 20, 295–304.
- De Neve M., De Buck S., Jacobs A., Van Montagu M., Depicker A. (1997) T-DNA integration patterns in co-transformed plant cells suggest that T-DNA repeats originate from ligation of separate T-DNAs. *Plant J.* 11, 15–29.
- Debeaujon I., Peeters A.J.M., Léon-Kloosterziel K.M., Koornneef M. (2001) The *TRANSPARENT TESTA12* gene of *Arabidopsis* encodes a multidrug secondary transporter-like protein required for flavonoid sequestration in vacuoles of the seed coat endothelium. *Plant Cell* 13, 853-871.
- Dhawale S., Souciet G., Kuhn, D.N. (1989) Increase of chalcone synthase mRNA in pathogen-induced soybeans with race-specific resistance is different in leaves and roots. *Plant Physiol.* 91, 911–916.
- Dixon R.A., Strack D. (2003) Phytochemistry meets genome analysis, and beyond. *Phytochemistry* 62, 815–816.
- Dixon R.A. (2001) Natural products and plant disease resistance. *Nature* 411, 843–847
- Dixon R.A., Paiva N. (1995) Stress-induced phenylpropanoid metabolism. *Plant Cell* 7, 1085–1097.
- Dixon R.A., Harrison M.J., Lamb C.J. (1994) Early events in the activation of plant defense responses. *Annu. Rev. Phytopath.* 32, 479-501.
- Dixon R.A., (1986) The phytoalexin response: elicitation, signaling, and control of host gene expression. *Biol. Rev. Camb. Philos. Soc.* 61, 239-192.
- Dooner H.K. (1983) Co-ordinate genetic regulation of flavonoid biosynthetic enzymes in maize. *Genetics* 91, 309-315.
- Dröge L.W., Kaiser A., Lindsay W.P., Halkier B.A., Loake G.J., Doerner P., Dixon R.A., Lamb C. (1997) Rapid stimulation of a soybean protein-serine kinase that phosphorylates a novel bZIP DNA-binding protein, G/HBF-1, during the induction of early transcription-dependent defenses. *EMBO J.* 16, 726–738.

## References

---

- Dron M., Clouse S.D., Dixon R.A., Lawton M.A., Lamb C.J. (1988) Glutathione and fungal elicitor regulation of a plant defense gene promoter in electroporated protoplasts. Proc. Natl. Acad. Sci. USA 85(18), 6738–6742.
- Durbin M.L., McCaig B., Clegg M.T. (2000) Molecular evolution of the chalcone synthase multigene family in the morning glory genome. Plant Mol. Biol. 42, 79-92.
- Edwards M.L., Stemmerick D.M., Sunkara P.S. (1990) Chalcones: a new class of antimitotic agents. J. Med. Chem. 33, 1948 – 1954.
- Ehmann B., Ocker B., Schafer E. (1991) Development and light dependent regulation of the expression of two different chalcone synthase transcripts in mustard cotyledons. Planta 183, 416-422.
- Elomaa P., Helariutta Y., Kotilainen M., Teeri T.H. (1996) Transformation of antisense constructs of the chalcone synthase gene superfamily into *Gerbera hybrida*: differential effect on the expression of family members. Mol. Breed. 2, 41–50.
- Estabrook E.M., Sengupta G.C. (1991) Differential expression of phenylalanine ammonia-lyase and chalcone synthase during soybean nodule development. Plant Cell 3, 299–308.
- Faktor O., Kooter J.M., Dixon R.A., Lamb C.J. (1996) Functional dissection of a bean chalcone synthase gene promoter in transgenic tobacco plants reveals sequence motifs essential for floral expression. Plant Mol. Biol. 32, 849-859.
- Faktor O., Kooter J.M., Loake G.J., Dixon R.A., Lamb C.J. (1997b) Differential utilization of regulatory cis-elements for stress-induced and tissue-specific activity of a French bean chalcone synthase promoter. Plant Sci. 124, 175- 182.
- Faktor O., Loake G., Dixon R.A., Lamb C.J. (1997a) The G-box and H-box in a 39 bp region of a French bean chalcone synthase promoter constitute a tissue-specific regulatory element. Plant J. 11, 1105–1113.
- Fan T.W.M. (1996) Metabolite profiling by one- and two-dimensional NMR analysis of complex mixtures. Progress in Nuclear Magnetic Resonance Spectroscopy 28, 161–219. Fernie A.R., Trethewey R.N., Krotzky A.J., Willmitzer L. (2004) Metabolite profiling: from diagnostics to systems biology. Nat. Rev. Mol. Cell Biol. 5, 763–769.

- Farmer E.E., Johnson R.R., Ryan C.A. (1992) Regulation of expression of proteinase inhibitor genes by methyl jasmonate and jasmonic acid. *Plant Physiol.* 98, 995–1002.
- Faulkner I.J., Rubery P.H. (1992). Flavonoids and flavonoid sulphates as probes of auxin-transport regulation in *Cucurbita pepo* hypocotyl segments and vesicles. *Planta* 186, 618–625.
- Feinbaum R.L., Storz G., Ausubel F.M. (1991) High intensity and blue light regulated expression of chimeric chalcone synthase genes in transgenic *Arabidopsis thaliana* plants. *Mol Gen Genet* 226, 449–456.
- Feinbaum R.L., Ausubel F.M. (1988). Transcriptional regulation of the *Arabidopsis thaliana* chalcone synthase gene. *Mol. Cell. Biol.* 8, 1985–1992.
- Feldbrügge M., Sprenger M., Hahlbrock K., Weisshaar B. (1997) PcMYB1, a novel plant protein containing a DNA-binding domain with one MYB repeat, interacts in vivo with a light-regulatory promoter unit. *Plant J.* 11, 1079–1093.
- Felton G.W., Korth K.L., Bi J.L., Wesley S.V., Huhman D.V., Mathews M.C., Murphy J.B., Lamb C., Dixon R.A. (1999) Inverse relationship between systemic resistance of plants to microorganisms and to insect herbivory, *Curr. Biol.* 9, 317–320.
- Ferrer J.L., Jez J.M., Bowman M.E., Dixon R.A., Noel, J.P. (1999) Structure of chalcone synthase and the molecular basis of plant polyketide biosynthesis. *Nat. Struct. Biol.* 6, 775–784.
- Feucht W., Treutter D., Polster J. (2004) Flavanol binding of nuclei from tree species. *Plant Cell Rep.* 22, 430–436.
- Fiehn O., Kopka J., Trethewey R.N., Willmitzer L. (2000). Identification of uncommon plant metabolites based on calculation of elemental compositions using gas chromatography and quadrupole mass spectrometry. *Anal. Chem.* 72, 3573–3580.
- Flavell R.B. (1994). Inactivation of gene expression in plants as a consequence of novel sequence duplications. *Proceedings of the National Academy of Sciences of the United States of America* 91, 3490–3496.
- Fliegmann J., Schröder G., Schanz S., Britsch L., Schröder J. (1992) Molecular analysis of chalcone and dihydropinosylvin synthase from Scots pine (*Pinus sylvestris*),

## References

---

- and differential regulation of these and related enzyme activities in stressed plants. *Plant Mol. Biol.* 18: 489–503.
- Friedrich L., Lawton K.A., Ruess W., Masner P., Specker N., Rella M.G., Meier B., Dincher S., Staub T., Uknes S., Metraux J.P., Kessmann H., Ryals J. (1996) A benzothiadiazole derivative induces systemic acquired resistance in tobacco, *Plant J.* 10, 61-70.
- Fritze K., Staiger D., Czaja, I., Walden R., Schell J., Wing D. (1991). Developmental and UV light regulation of the snapdragon chalcone synthase promoter. *Plant Cell* 3, 893-905.
- Frohnmyer H., Bowler C., Schaefer E. (1997) Evidence for some signal transduction elements involved in UV-light dependent responses in parsley protoplasts. *J. Exp. Bot.* 48, 739–750.
- Frohnmyer H., Ehmann B., Kretsch T., Rocholl M., Harter K., Nagatani A., Furuya M., Batschauer A., Hahlbrock K., Schaefer E. (1992) Differential usage of photoreceptors for chalcone synthase gene expression during plant development. *Plant J.* 2, 899–906.
- Frohnmyer H., Staiger D. (2003) Ultraviolet-B radiation-mediated responses in plants. Balancing damage and protection. *Plant Physiol.* 133, 1420–1428.
- Fuglevand G., Jackson J.A., Jenkins G.I. (1996) UV-B, UV-A, and blue light signal transduction pathways interact synergistically to regulate chalcone synthase gene expression in *Arabidopsis*. *Plant Cell* 8, 2347–2357.
- Furner I.J., Sheikh M.A., Collett C.E. (1998) Gene silencing and homology-dependent gene silencing in *Arabidopsis*: genetic modifiers and DNA methylation. *Genetics* 149, 651–662.
- Garcia I., Rodgers M., Pepin R., Hsieh T.F., Matringe M. (1999) Characterization and Subcellular Compartmentation of Recombinant 4-Hydroxyphenylpyruvate Dioxygenase from *Arabidopsis* in Transgenic Tobacco. *Plant Physiol.* 119, 1507-1516.
- Gehm B.D., McAndrews J.M., Chien P.Y., Jameson J.L. (1997) Resveratrol, a polyphenolic compound found in grapes and wine, is an agonist for the estrogen receptor. *Proc. Natl. Acad. Sci. USA* 94, 14138–14143.

- Gläßgen W.E., Rose A., Madlung J., Koch W., Gleitz J., Seitz H.U. (1998) Regulation of enzymes involved in anthocyanin biosynthesis in carrot cell cultures in response to treatment with ultraviolet light and fungal elicitors. *Planta* 204, 490–498.
- Görlach J., Volrath S., Knauf-Beiter G., Hengy G., Beckhove U., Kogel K.H., Staub M.T., Ward E., Kessmann H., Ryals J. (1996) Benzothiadiazole, a novel class of inducers of systemic acquired resistance, activates expression and disease resistance in wheat, *Plant Cell* 8, 629–643.
- Graham T. (1998) Flavonoid and flavonol glycoside metabolism in *Arabidopsis*. *Plant Physiol. Biochem.* 36, 165-144.
- Grandmaison J., Ibrahim, R.K. (1996) Evidence for nuclear protein binding of flavonol sulfate esters in *Flaveria chloraeefolia*. *J. Plant Physiol.* 147, 653-660.
- Gregersen P.L. Christensen A.B. Sommer-Knudsen J. Collinge D.B. (1994) A putative O-methyltransferase from barley is induced by fungal pathogens and UV light. *Plant Mol. Biol.* 26, 1797-1806.
- Grotewold E., Chamberlin M., Snook M., Siame B., Butler L., Swenson J., Maddock S., St. Clair G., Bowen B. (1998) Engineering secondary metabolism in maize cells by ectopic expression of transcription factors. *Plant Cell* 10, 721-740.
- Guetsky R., Kobiler I., Wang X., Perlman N., Gollop N., Avila-Quezada G., Hadar I., Prusky D. (2005) Metabolism of the flavonoid epicatechin by laccase of *Colletotrichum gloeosporioides* and its effect on pathogenicity on avocado fruits. *Phytopathology* 95, 1341–1348.
- Hahlbrock K., Scheel D. (1989) Physiology and molecular biology of phenylpropanoid metabolism. *Annu. Rev. Plant Physiol. Plant Mol. Biol.* 40, 347–369.
- Hahlbrock K. (1981) Flavonoids. In *The Biochemistry of Plants*, Vol. 7, P.K. Stumpf and E.E. Conn, eds (New York: Academic Press), 425–456.
- Hahlbrock K., Grisebach H . (1979) Enzymatic controls in the biosynthesis of lignin and flavonoids . *Annu. Rev. Plant Physiol.* 30,105-130
- Hahlbrock K., Zilg H., Grisebach H. (1970) Stereochemistry of the enzymatic cyclisation of 4,2',4'-trihydroxychalcone to 7,4'-dihydroxyflavanone by isomerases from Mung Bean seedlings. *Eur. J. Biochem.* 15, 13-18.

## References

---

- Hammond S.M., Caudy A.A., Hannon G.J. (2001) Post-transcriptional gene silencing by double-stranded RNA. *Nat. Rev. Genet.* 2, 110–119.
- Hannon G. J. (2002) RNA interference. *Nature* 418, 244–251.
- Harborne J.B., Grayer R.J. (1994) Flavonoids and insects. In: *The Flavonoids, Advances in Research since 1986*, Chapman & Hall, London, 589–618.
- Harborne J.B., Williams C.A. (2000) Advances in flavonoid research since 1992. *Phytochemistry* 55, 481–504.
- Harker C.L., Ellis T.H., Coen, E.S. (1990). Identification and genetic regulation of the chalcone synthase multigene family in pea. *Plant Cell* 2, 185–194.
- Harker C.L., Ellis T.H.N., Coen E.S. (1990) Identification and genetic regulation of the chalcone synthase multigene family in pea. *Plant Cell* 2, 185–194.
- Harrison M.J., Dixon. R.A (1993) Isoflavonoid accumulation and expression of defense gene transcripts during the establishment of vesicular-arbuscular mycorrhizal associations in roots of *Medicago truncatula*. *Mol. Plant Microb. Interact.* 5, 643–654.
- Harrison M.J., Lawton M.A., Lamb C.J., Dixon R.A. (1991) Characterization of a nuclear protein that binds to three elements within the silencer region of a bean chalcone synthase gene promoter. *Proc. Natl. Acad. Sci. USA* 88, 2515–2519.
- Hartmann U., Valentine W.J., Christie J.M., Hays J., Jenkins G.I., Weisshaar B. (1998) Identification of UV/blue light-response elements in the *Arabidopsis thaliana* chalcone synthase promoter using a homologous protoplast transient expression system. *Plant Mol. Biol.* 36, 741–754.
- Haussuehl K.K., Rohde W., Weissenboeck G. (1996) Expression of chalcone synthase genes in coleoptiles and primary leaves of *Secale cereale* L. after induction by UV radiation: evidence for a UV protective role of the coleoptiles. *Bot. Acta* 109, 229–238.
- Helariutta Y., Kotilainen M., Elomaa P., Kalkkinen N., Bremer K., Teeri T.H., Albert V.A. (1996) Duplication and functional divergence in the chalcone synthase gene family of Asteraceae: evolution with substrate change and catalytic simplification. *Proc. Natl. Acad. Sci. USA* 93, 9033–9038.
- Hendrawati O., Yao Q., Kim H.K., Linthorst H.J.M., Erkelens C., Lefeber A.W.M., Choi Y.H., Verpoorte R. (2006) Metabolic differentiation of *Arabidopsis*

- treated with methyl jasmonate using nuclear magnetic resonance spectroscopy, Plant Sci. 170, 1118-1124.
- Hinderer W., Seitz H.U. (1985) Chalcone synthase from cell suspension cultures of *Daucus carota* L. Arch. Biochem. Biophys. 240, 265-272.
- Hipskind J, Hanau R, Leite B, Nicholson RL (1990) Phytoalexin synthesis in sorghum: identification of an apigeninidin acyl ester. Physiol. Mol. Plant. Pathol. 36, 381-396.
- Hirai M.Y. Hirai, Yano M. Yano, D.B. Goodenowe, S. Kanaya, T. Kimura, M. Awazuhara, Arita M. Arita, Fujiwara T. Fujiwara, Saito K. Saito(2004) Integration of transcriptomics and metabolomics for understanding of global responses to nutritional stresses in *Arabidopsis thaliana*, Proc. Natl. Acad. Sci. USA 101, 10205-10210.
- Holton T.A., Cornish E.C. (1995) Genetics and biochemistry of anthocyanin biosynthesis. Plant Cell 7, 1071–1083.
- Hrazdina G., Jensen R. A. (1992) Spatial Organization of Enzymes in Plant Metabolic Pathways. Ann. Rev. Plant Physiol. Plant Mol. Biol. 43, 241-267.
- Hrazdina G., Kreuzaler F., Hahlbrock K, Grisebach H. (1976) Substrate specificity of flavanone synthase from cell suspension cultures of parsley and structure of release products *in vitro*. Arch. Biochem. Biophys. 175, 392-399.
- Hrazdina G., Marx F.A., Hoch H.C. (1982) Distribution of secondary plant metabolites and their biosynthetic enzymes in pea (*Pisum sativum* L.) leaves. Plant Physiol. 70, 745-748.
- Hrazdina G., Wagner G. J. (1985) Metabolic pathways as enzyme complexes: evidence for the synthesis of phenylpropanoids and flavonoids on membrane associated enzyme complexes. Annu. Proc. Phytochem. Soc. Europe 25, 120-133.
- Hutzler P., Rischbach R., Heller W., Jungblut T. P., Reuber S., Schmitz R., Veit M., Weissenbck G., Schmitzler J.-P. (1998) Tissue localization of phenolic compounds in plants by confocal laser scanning microscopy. J. Exp. Bot. 49, 953-965.
- Inbar, M., Doostdar H., Gerling D., Mayer R. T. (2001) Induction of systemic acquired resistance in cotton by BTH has a negligible effect on phytophagous insects, Entomol. Exp. Appl. 99, 65-70.

## References

---

- Ingelbrecht I., Van Houdt H., Van Montagu M., Depicker A. (1994) Posttranscriptional silencing of reporter transgenes in tobacco correlates with DNA methylation. Proc. Natl. Acad. Sci. USA 91, 10502–10506.
- Ingham D.J., Beer S., Money S., Hansen G. (2001). Quantitative real-time PCR assay for determining transgene copy number in transformed plants. Biotechniques 31, 132–140.
- Ingham J.L. (1976) Induced and constitutive isoflavonoids from stems of chickpeas (*Cicer arietinum* L.) inoculated with spores of *Helminthosporium carbonum* Ullstrup. J. Phytopathol. 87, 353 – 367.
- Iriti M., Rossoni M., Borgo M., Faoro F. (2004) Benzothiadiazole enhances resveratrol and anthocyanin biosynthesis in grapevine, meanwhile improving resistance to *Botrytis cinerea*, J. Agric. Food Chem. 52, 4406- 4413.
- Ito M., Ichinose Y., Kato H., Shiraishi T., Yamada T. (1997) Molecular evolution and functional relevance of the chalcone synthase genes of pea. Mol. Gen. Genet. 255: 28–37.
- Iyer L.M., Kumpatla S.P., Chandrasekharan M.B., Hall T.C. (2000) Transgene silencing in monocots. Plant Mol. Biol. 43, 323–346.
- Jacobs M., Rubery P.H. (1988) Naturally occurring auxin transport regulators. Science 241, 346-349.
- Jahangir M., Kim H.K., Choi Y.H., Verpoorte R. (2008) Metabolomic response of *Brassica rapa* submitted to pre-harvest bacterial contamination. Food Chemistry 107, 362-368.
- Jang M., Cai L., Udeani G.O., Slowing K.V., Thomas C.F., Beecher C.W., Fong H.H.S., Farnsworth N.R., Kinghorn A.D., Mehta R.G., Moon R.C., Pezzuto J.M. (1997) Cancer chemo preventive activity of resveratrol, a natural product derived from Grape, Science 275, 218-220.
- Jang M.S., Cai E.N., Udeani G.O., Slowing K.V., Thomas C.F., Beecher C.W.W., Fong H.H.S., Fransworth N.R., Kinghorn A.D., Mehta R.G., Moon R.C., Pezzuto J.M. (1997) Cancer Chemopreventive Activity of Resveratrol, a Natural Product Derived from Grapes. Science 275, 218-220.
- Jenkins G.I. (1997) UV and blue light signal transduction in *Arabidopsis*. Plant Cell Environ 20, 773-778.

- Jenkins G.I., Long J.C., Wade H.K., Shenton M.R., Bibikova T.N. (2001) UV and blue light signalling: pathways regulating chalcone synthase gene expression in *Arabidopsis*. *New Phytol.* 151 (1), 121–131.
- Jez J.M., Austin M.B., Ferrer J.L., Bowman M.E., Schröder J., Noel J.P. (2000) Structural control of polyketide formation in plant-specific polyketide synthases. *Chem. Biol.* 40, 1–12.
- Jez J.M., Bowman M.E., Noel J.P. (2001a) Structure-guided programming of polyketide chain-length determination in chalcone synthase. *Biochemistry* 40, 14829–14838.
- Jez J.M., Ferrer J.L., Bowman M.E., Austin M.B., Schröder J., Dixon R.A., Noel J.P. (2001b) Structure and mechanism of chalcone synthase-like polyketide synthases. *J. Ind. Microbiol. Biotechnol.* 27, 393–398.
- John D., Hipskind J.D., Robert Hanau R., Breno Leite B., Ralph L. Nicholson R.L. (1990) Phytoalexin accumulation in sorghum: identification of an apigeninidin acyl ester. *Physiol. Mol. Plant Path.* 36, 381–396.
- Johnson G., Maag D.D., Johnson D.K., Thomas R.D. (1976) The possible role of phytoalexins in the resistance of sugarbeet (*Beta vulgaris*) to *Cercospora beticola* [Fungal pathogens]. *Physiol. Plant Path.* 8, 225–230
- Jorgensen R.A. (1995) Cosuppression, flower color patterns, and metastable gene expression states. *Science* 268, 686–691.
- Junghans H., Dalkin K., Dixon R.A. (1993) Stress responses in alfalfa (*Medicago sativa* L.). 15. Characterization and expression patterns of members of a subset of the chalcone synthase multigene family. *Plant Mol. Biol.* 22, 239–253.
- Kaiser T., Batschauer A. (1995) *Cis*-acting elements of the *CHS1* gene from white mustard controlling promoter activity and spatial patterns of expression. *Plant Mol. Biol.* 28, 231–243.
- Kaiser T., Emmler K., Kretsch T., Weisshaar B., Schafer E., Batschauer A. (1995). Promoter elements of the mustard *CHS7* gene are sufficient for light-regulation in transgenic plants. *Plant Mol. Biol.* 28, 219–229
- Kataoka K., Uemachi A., Yazawa S. (2003) Fruit growth and pseudoembryo development affected by uniconazole, an inhibitor of gibberellin biosynthesis, in *pat-2* and auxin-induced parthenocarpic tomato fruits *Sci. Hort.* 98, 9–16.

## References

---

- Katz V.A., Thulke O.U., Conrath U. (1998) A benzothiadiazole primes parsley cells for augmented elicitation of defense responses, *Plant Physiol.* 8, 1333–1339.
- Kaulen H., Schell J., Kreuzaler F. (1986) Light-induced expression of the chimeric chalcone synthase-NPTII gene in tobacco cells. *EMBO J.* 5, 1–8.
- Keasling J.D., Vandien S.J., Pramanik J. (1998) Engineering polyphosphate metabolism in *Escherichia coli* - implications for bioremediation of inorganic contaminants. *Biotech. Bioeng.* 58, 231-239.
- Kerhoas L., Aouak D., Cingoz A., Routaboul J.M., Lepiniec L., Einhorn J., Birlirakis N. (2006) Structural characterization of the major flavonoid glycosides from *Arabidopsis thaliana* seeds. *J. Agric. Food Chem.* 54, 6603–6612.
- Kessmann H., Staub T., Hofmann C., Maetzke T., Herzog J., Ward E., Ukness S., Ryals J. (1994) Induction of systemic acquired resistance in plants by chemicals. *Annu. Rev. Phytopathol.* 32, 439-459.
- Knogge W., Schmelzer E., Weissenböck G. (1986) The role of chalcone synthase in the regulation of flavonoid biosynthesis in developing oat primary leaves. *Arch. Biochem. Biophys.* 250, 364–372.
- Kodama O., Miyakawa J., Akatsuka T., Kiyosawa S. (1992) Sakuranetin, a flavanone phytoalexin from ultraviolet-irradiated rice leaves. *Phytochemistry* 31, 3807–3809.
- Koes R.E., Spelt C.E., Mol J.N.M. (1989) The chalcone synthase multigene family of *Petunia hybrida* (V30): differential, light-regulated expression during flower development and UV light induction. *Plant Mol. Biol.* 12, 213–225.
- Koes R.E., Spelt C.E., Mol J.N.M., Gerats A.G.M. (1987) The chalcone synthase multigene family of *Petunia hybrida*: sequence homology, chromosomal localization and evolutionary aspects. *Plant Mol. Biol.* 10, 159–169.
- Koes R.E., Spelt C.E., Reif H.J., van den Elzen P.J.M., Veltkamp E., Mol J.N.M. (1986) Floral tissue of *Petunia hybrida* (V30) expresses only one member of the chalcone synthase multigene family. *Nucleic Acids Res.* 11 (14), 5229 - 5239.
- Kohli A., Leech M., Vain P., Laurie D.A., Christou P. (1998) Transgene organization in rice engineered through direct DNA transfer supports a two-phase integration mechanism mediated by the establishment of integration hot spots. *Proc. Natl. Acad. Sci. USA* 95, 7203–7208.

- Kolbe A., Oliver S.N., Fernie A.R., Stitt M., van Dongen J.T., Geigenberger P. (2006) Combined Transcript and Metabolite Profiling of Arabidopsis Leaves Reveals Fundamental Effects of the Thiol-Disulfide Status on Plant Metabolism, *Plant Physiol.* 141, 412-422.
- Kombrink E., Somissich I. E. (1997) Pathogenesis-related proteins and plant defense in: Carrol G. C., Tudzynski P. (Eds), *The Mycota V part A, plant Relationships*, Springer-Verlag, Berlin, 107-128.
- Kong J.M., Chia L.S., Goh N.K., Chia T.F., Brouillard R. (2003) Analysis and biological activities of anthocyanins. *Phytochemistry* 64, 923–933.
- Kraemer K.H., Schenkel E.P., Verpoorte R. (2002) *Ilex paraguariensis* cell suspension culture characterization and response against ethanol, *Plant Cell Tissue Organ Cult.* 68, 257-263.
- Kreuzaler F., Hahlbrock K. (1975) Enzymatic synthesis of an aromatic ring from acetate units. Partial purification and some properties of flavanone synthase from cell-suspension cultures of *Petroselinum hortense*. *Eur. J. Biochem.* 56, 205-213.
- Kreuzaler F., Ragg H., Fautz E., Kuhn D.N., Hahlbrock K. (1983) UV-induction of chalcone synthase mRNA in cell suspension cultures of *Petroselinum hortense*. *Proc. Natl. Acad. Sci. USA* 80, 2591–2593.
- Krishnan P., Kruger N.J., Ratcliffe R.G. (2005) Metabolite fingerprinting and profiling in plants using NMR. *J. Exp. Bot.* 56, 255-265.
- Kubasek W.L., Shirley B.W., Mc Killop A., Goodman H.M., Briggs W., Ausubel F.M. (1992) Regulation of flavonoid biosynthetic genes in germinating *Arabidopsis* seedlings. *Plant Cell* 4, 1229-1236.
- Kuć J. (1982) Induced immunity to plant disease, *Bioscience* 32, 854-856.
- Kuhn D.N. (1988) Plant stress responses: Discussion of models for race-specific resistance. *Recent. Adv. Phytochem.* 22, 127-161.
- Kuhn D.N., Chappell J., Boudet A., Hahlbrock K. (1984) Induction of phenylalanine ammonia-lyase and 4-coumarate:CoA ligase mRNAs in cultured plant cells by UV light or fungal elicitor. *Proc. Natl. Acad. Sci. USA* 81, 1102-1106.

## References

---

- Kuras M., Stefanowska-Wronka M., Lynch J.M., Zobel A.M. (1999) Cytochemical localization of phenolic compounds in columella cells of the root cap in seeds of *Brassica napus*—changes in the localization of phenolic compounds during germination. Ann. Bot. 84, 135-143.
- Kurosaki F., Amin M., Nishi A. (1986) Induction of phytoalexin production and accumulation of phenolic compounds in cultured carrot cells. Pysiol. Mol. Plant Pathol. 28, 359-370.
- Langcake P., Pryce R.J. (1977a) A new class of phytoalexins from grapevines. Experientia 33, 151–152.
- Langcake P., Pryce R.J. (1977b) The production of resveratrol and the viniferins by grapevines in response to ultraviolet irradiation. Phytochemistry 16, 1193–1196.
- Lanz T., Tropf S., Marner F.J., Schröder J., Schröder G. (1991) The role of cysteines in polyketide synthases: site-directed mutagenesis of resveratrol and chalcone synthases, two key enzymes in different plant-specific pathways. J. Biol. Chem. 266, 9971–9976
- Lawson C.G.R., Djordjevic M.A., Weinman J.J., Rolfe B.G. (1994) *Rhizobium* inoculation and physical wounding result in the rapid induction of the same chalcone synthase copy in *Trifolium subterraneum*. Mol. Plant Microb. Interact. 7, 498 507.
- Lawton K.A., Friedrich L., Hunt M., Weymann K., Delaney T., Kessmann H., Staub T., Ryals J. (1996) Benzothiadiazole induces disease resistance in *Arabidopsis* by activation of the systemic acquired resistance signal transduction pathway, Plant J. 10, 71-82.
- Lawton M.A., Clouse S.D., Lamb C.J. (1990). Glutathione-elicited changes in chromatin structure within the promoter of the defense gene chalcone synthase. Plant Cell Rep. 8, 561–564.
- Lawton M.A., Lamb C.J. (1987) Transcriptional activation of plant defense genes by fungal elicitor, wounding, and infection. Mol. Cell. Biol. 7, 335 341.
- Le Gall G., Metzdorff S.B., Pedersen J., Bennett R.N., Colquhoun I.J. (2005) Metabolite profiling of *Arabidopsis thaliana* (L.) plants transformed with an antisense chalcone synthase gene. Metabolomics 1, 181-198.

- Lessard R., Rochette P., Gregorich E.G., Pattey E., Desjardins R.L., (1996) Nitrous oxide fluxes from manure-amended soil under maize. *J. Environ. Qual.* 25, 1371–1377.
- Leyva A., Jarillo T.A., Salinas J., Martinez-Zapater J.M. (1995) Low temperature induces the accumulation of phenylalanine ammonia-lyase and chalcone synthase mRNAs of *Arabidopsis thaliana* in a light-dependent manner. *Plant Physiol.* 108, 39–46.
- Li J., Lee T.M.O., Raba R., Amundson R.G., Last R.L. (1993) Arabidopsis flavonoid mutants are hypersensitive to UV-B irradiation. *Plant Cell* 5, 171-179.
- Li R.S., Kenyon G.L., Cohen F.E., Chen X.W., Gong B.Q., Dominquez J.N., Davidson E., Kurzban G., Miller R.E., Nuzum E.O., Rosenthal P.J., McKerrow J.H. (1995) In Vitro Antimalarial Activity of Chalcones and Their Derivatives *J. Med. Chem.* 38, 5031 - 5037.
- Li X.Q., Li S.H., Chen D.F., Meng F.R. (2004) Induced Activity of Superoxide Dismutase and Peroxidase of *in vitro* Plants by Low Concentrations of Ethanol, *Plant Cell Tissue Organ Cult.* 79, 83-86.
- Li Z., Hansen J.L., Liu Y., Zemetra R.S., Berger P.H. (2004) Using real-time PCR to determine transgene copy number in wheat. *Plant Mol. Bio. Rep.* 22, 179–188.
- Liang Y.S., Kim H. K., Lefeber A. W. M., Erkelens C., Choi Y. H., Verpoorte R. (2006) Identification of phenylpropanoids in *Brassica rapa* leaves treated with methyl jasmonate using two-dimensional nuclear magnetic resonance spectroscopy. *J. Chromatogr. A* 1112, 148-155.
- Liang Y.S., Kim H.K., Linthorst H.J.M., Choi Y.H., Verpoorte R., Metabolomic analysis of methyl jasmonate treated *Brassica rapa* leaves by 2-dimensional NMR spectroscopy, *Phytochemistry* 67 (2006) 2503-2511.
- Lin C. (2000) Plant blue-light receptors. *Trends Plant Sci.* 5, 337-342.
- Lin Y., Irani N.G., and Grotewold E. (2003) Sub-cellular trafficking of phytochemicals explored using auto-fluorescent compounds in maize cells. *BMC Plant Biol.* 3, 1011-1012.
- Liphhardt S., Brettschneider R., Kreuzaler F., Schell J., Dangl J.L. (1988) UV-inducible transient expression in parsley protoplasts identifies regulatory *cis*-elements of

## References

---

- a chimeric *Antirrhinum majus* chalcone synthase gene. EMBO J. 7, 4027–4033.
- Liu D., Raghothama K. G., Hasegawa P. M., Bressan R. A., Osmotin overexpression in potato delays development of disease symptoms, Proc. Natl. Acad. Sci. USA 91 (1994) 1888-1892.
- Livak K.J., Schmittgen T.D. (2001) Analysis of relative gene expression data using real-time quantitative PCR and the 2( $-\Delta\Delta C(T)$ ) method. Methods 25, 402–408.
- Lo S.C., Hipskind J.D., Nicholson R.L. (1998) cDNA cloning of a sorghum pathogenesis-related protein (PR-10) and differential expression of defense-related genes following inoculation with *Cochliobolus heterostrophus* or *Colletotrichum sublineolum*. Mol. Plant Microb. Interact. 12, 479-489.
- Loake G.J., Faktor O., Lamb C.J., Dixon R.A. (1992) Combination of H box (CCTACCN7CT) and G box (CACGTG) *cis* elements is necessary for feed-forward stimulation of a chalcone synthase promoter by the phenylpropanoid pathway intermediate p-coumaric acid. Proc. Natl. Acad. Sci. USA 89, 2930–2934.
- Logemann E., Tavernaro A., Schulz W., Somssich I. E., Hahlbrock K. (2000) UV light selectively coinduces supply pathways from primary metabolism and flavonoid secondary product formation in parsley. Proc. Natl. Acad. Sci. USA 97, 1903-1907.
- Lois R. (1994) Accumulation of UV-absorbing flavonoids induced by UV-B radiation in *Arabidopsis thaliana* L. I. Mechanisms of UV resistance in Arabidopsis. Planta 194, 498-503.
- Lois R., Dietrich A., Hahlbrock K., Schulz W. (1989) A phenylalanine ammonia-lyase from parsley: structure, regulation and identification of elicitor and light responsive *cis*-acting elements. EMBO J. 8, 1641–1648.
- Long J.C., Jenkins G.I. (1998) Involvement of Plasma Membrane Redox Activity and Calcium Homeostasis in the UV-B and UV-A /Blue Light Induction of Gene Expression in Arabidopsis. Plant Cell 10, 2077–2086.
- Loyall L., Uchida K., Braun S., Furuya M., Frohnmyer H. (2000) Glutathione and a UV light-induced glutathione *S*-transferase are involved in signaling to

- chalcone synthase in cell cultures. The first indication that tau GSTs are involved in plant cell stress signaling. *Plant Cell.* 12, 1939–1950.
- Ludwig, S.R., Habera, L.F., Dellaporta, S.L., Wessler, S.R. (1989) *Lc*, a member of the maize *R* gene family responsible for tissue-specific anthocyanin production, encodes a protein similar to transcription activators and contains the *myc*-homology region. *Proc. Natl. Acad. Sci. USA* 86, 7092-7096.
- Lue W.L., Kuhn D., Nicholson R.L. (1989) Chalcone synthase activity in sorghum mesocotyls inoculated with *Colletotrichum graminicola*. *Physiol. Mol. Plant Pathol.* 35, 413-422.
- Mackerness S., John C.F., Jordan B.R., Thomas B. (2001) Early signaling components in ultraviolet-B responses: distinct roles for different reactive oxygen species and nitric oxide. *FEBS Lett.* 489, 237–242.
- Manach C., Scalbert A., Morand C., Rémesy C., Jimenez L. (2004) Polyphenols: food sources and bioavailability. *Am. J. Clin. Nutr.* 79, 727-747.
- Markham, K.R., Gould, K.S., Ryan K.G. (2001) Cytoplasmic accumulation of flavonoids in flower petals and its relevance to yellow flower colouration. *Phytochemistry* 58, 403-413.
- Marles M.A., Ray H., Gruber M.Y. (2003) New perspectives on proanthocyanidin biochemistry and molecular regulation. *Phytochemistry* 64, 367–383.
- Martin C.R. (1993) Structure, function and regulation of the chalcone synthase. *Int. Rev. Cytol* 147, 233–284.
- Mathews H., Clendennen S.K., Caldwell C.G., Liu XL., Connors, K., Mattheis N., Schuster D.K., Menasco D.J., Wagoner W., Lightner J., Wagner D.R. (2003) *Plant Cell* 15, 1689-1703.
- Matthews D.E., Matthews P.S. (1989) Phytoalexin detoxification: Importance for pathogen city and practical implications. *Annu. Rev. Phytopath.* 27, 143–164.
- Mauch F., Mauch-Mani B., Boller T. (1988) Antifungal hydrolases in pea tissue. 2. Induction of chitinase and b-1,3-glucanase in pea pods by pathogens and elicitors. *Plant Physiol.* 76, 936-942.
- Meier B.M., Shaw N., Slusarenko A.J. (1993) Spatial and temporal accumulation of defense gene transcripts in bean (*Phaseolus vulgaris*) leaves in relation to

## References

---

- bacteria-induced hypersensitive cell death. Mol. Plant Microb. Interact. 6, 453–466.
- Mert T.F., Bennet M.H., Mansfield J.W., Holub E.B. (2003) Camalexin accumulation in *Arabidopsis thaliana* following abiotic elicitation or inoculation with virulent or avirulent *Hyaloperonospora parasitica*. Physiol. Mol. Plant Pathol. 62, 137–145.
- Métraux J.P., Signer H., Ryals J., Ward E., Wyss-Benz M., Gaudin J., Raschdorf K., Schmid E., Blum W., Inverardi B. (1990) Increase in salicylic acid at the onset of systemic acquired resistance in cucumber, Science 250, 1004-1006.
- Mitrecic D., Huzak M., Curlin M., Gajovic S. (2005) An improved method for determination of gene copy numbers in transgenic mice by serial dilution curves obtained by real-time quantitative PCR assay. J. Biochem. Biophys. Methods 64(2), 83-98.
- Mol J. N. M., Robbins M. P., Dixon R. A., Veltkamp E.. (1985). Spontaneous and enzymic rearrangement of naringenin chalcone to flavanone. Phytochemistry 24, 2267-2269.
- Mol J.N.M., Stuitje A., Gerats A., Koes R. (1988) Cloned genes of plant phenylpropanoid metabolism. Plant Mol. Biol. Rep. 6, 274–279.
- Mol N.J.J., Schram A.W., de Vlaming P., Gerats A.G.M., Kreuzaler F., Hahlbrock K., Reif H.J., Veltkamp E. (1983) Regulation of flavonoid gene expression in *Petunia hybrida*: description and partial characterization of a conditional mutant in chalcone synthase gene expression. Mol. Gen. Genet. 192, 424–429.
- Monache G.D., Botta B., Vinciguerra V., de Mello J.F., Andrade Chiapetta de A. (1996) Antimicrobial isoflavanones from *Desmodium canum*. Phytochemistry 41, 537-544.
- Moriguchi T., Kita M., Tomono Y., Endo-Inagaki T., Omura M. (1999) One type of chalcone synthase gene expressed during embryogenesis regulates the flavonoid accumulation in citrus cell cultures. Plant Cell Physiol. 40, 651–655.
- Morita H., Takahashi Y., Noguchi H., Abe I. (2000) Enzymatic formation of unnatural aromatic polyketides by chalcone synthase. Biochem. Biophys. Res. Commun. 279, 190–195.

- Morkunas I., Marczak L., Stachowiak J., Stobiecki M. (2005) Sucrose-induced lupine defense against *Fusarium oxysporum*: Sucrose-stimulated accumulation of isoflavonoids as a defense response of lupine to *Fusarium oxysporum*. *Plant Physiol. Biochem.* 43, 363-373.
- Nagy N.E., Fosdal C.G., Krokene P., Krekling T., Lonneborg A., Solheim H. (2004) Induced responses to pathogen infection in Norway spruce phloem: changes in polyphenolic parenchyma cells, chalcone synthase transcript levels and peroxidase activity. *Tree Physiol.* 24, 505-515.
- Naidu R.A., Collins G.B., Ghabrial S.A. (1991) Nucleotide sequence analysis of a cDNA clone encoding the coat protein gene of peanut stunt virus. *Plant Mol. Biol.* 16, 175–185.
- Nakamura N., Nakamae H., Maekawa L. (1980) Effects of light and kinetin on anthocyanin accumulation in the petals of *Rosa hybrida*, Hort cv. Ehigasa. *Z. Pflanzenphysiol.* 98, 263-270.
- Napoli C., Lemieux C., Jorgensen R.A. (1990) Introduction of a chimeric chalcone synthase gene into Petunia results in reversible co-suppression of homologous genes in trans. *Plant Cell* 2, 279–289.
- Nicholson R.L., Kollipara S.S. Vincent J.R., Lyons P.C., Cadena-Gomez G. (1987) Phytoalexin synthesis by the sorghum mesocotyl in response to infection by pathogenic and nonpathogenic fungi. *Proc. Natl. Acad. Sci. USA* 84, 5520-5524.
- Nijveldt R.J., van Nood E., van Hoorn D.E.C., Boelens P.G., van Norren K., van Leeuwen P.A.M. (2001) Flavonoids : A review of probable mechanisms of action and potential applications. *Am. J. Clin. Nutr.* 74, 418–425.
- Novák P., Krofta K., Matoušek J. (2006) Chalcone synthase homologues from *Humulus lupulus*: some enzymatic properties and expression. *Biol. Plant.* 50, 48–54.
- Ohl S., Hahlbrock K., Schafer, E. (1989) A stable blue-lightderived signal modulates ultraviolet-light-induced activation of the chalcone-synthase gene in cultured parsley cells. *Planta* 177, 228-236.
- Ohto M.A., Onai K., Furukawa Y., Aoki E., Araki T., Nakamura K. (2001) Effects of sugar on vegetative development and floral transition in *Arabidopsis*. *Plant Physiol.* 127, 252–261.

## References

---

- Oksman-Caldentey K.M., Saito K. (2005) Integrating genomics and metabolomics for engineering plant metabolic pathways, *Curr. Opin. Biotech.* 16, 174-179.
- Oku H., Ouchi S., Shiraishi T., Komoto Y., Oki K. (1975) Phytoalexin activity in barley powdery mildew. *Ann. Phyto. Path. Soc. Japan* 41, 185–191
- Panke S., Sanchezromero J. M. (1998) Engineering of quasi-natural *Pseudomonas putida* strains for toluene metabolism through an ortho-cleavage degradation pathway. *Appl. Environ. Microbiol.* 64, 748-751.
- Pare P.W., Mischke C.F., Edwards R., Dixon R.A., Norman H.A., Mabry T.J. (1992) Induction of phenylpropanoid pathway enzymes in elicitor-treated cultures of *Cephalocereus senilis*, *Phytochemistry* 31, 149-153.
- Pare, P.W., : Mischek, C.F., : Edwards, R., : Dixon, R.A., : Norman, H.A., : Mabry, T.J. (1992) Induction of phenylpropanoid pathway enzymes in elicitor-treated cultures of *Cephalocereus senilis*. *Phytochemistry* 31, 149-153.
- Paz-Ares J., Wlenand U., Peterson P.A., Saedler H. (1986). Molecular cloning of the c locus of *Zea mays*: A locus regulating the anthocyanin pathway. *EMBO J.* 5, 829-833.
- Peer W.A., Brown D.E., Tague B.W., Muday G.K., Taiz L., Murphy A.S. (2001) Flavonoid accumulation patterns of transparent testa mutants of *Arabidopsis*. *Plant Physiol.* 126, 536–548.
- Perrot G.H., Cone K.C. (1989) Nucleotide sequence of the maize R-S gene. *Nucl. Acids Res.* 17, 8003.
- Peters A., Schneider-Poetsch H.J., Schwarz H., Weissenböck G. (1988) Biochemical and immunological characterization of chalcone synthase from rye leaves. *J. Plant Physiol.* 133, 178-182.
- Peterson G.L. (1977) A simplification of the protein assay method of Lowry et al. which is generally more applicable. *Anal. Biochem.* 83, 346-356.
- Qian W., Tan G., Liu H., He S., Gao Y., An C. (2007) Identification of a bHLH-type G-box binding factor and its regulation activity with G-box and Box I elements of the *PsCHS1* promoter. *Plant Cell Rep.* 26, 85–93.
- Raharjo T. J., (2004) Studies of cannabinoid biosynthesis in *Cannabis sativa* L.: The polyketide synthase, PhD thesis, Leiden University, Leiden, The Netherlands.

- Rasmussen S., Dixon R.A. (1999) Transgene-mediated and elicitor-induced perturbation of metabolic channeling at the entry point into the phenylpropanoid pathway. *Plant Cell* 11, 1537-1551.
- Reuber S., Bornman J.F., Weissenoek G. (1996) A flavonoid mutant of barley (*Hordeum vulgare L.*) exhibits increased sensitivity to UV-B radiation in the primary leaf. *Plant Cell Envir.* 19, 593–601
- Reymond P., Short T., Briggs W.R., Poff K.L. (1992). Light induced phosphorylation of a membrane protein plays an early role in signal transduction for phototropism in *Arabidopsis thaliana*. *Proc. Natl. Acad. Sci. USA* 89, 4718-4721.
- Richard S., Lapointe G., Rutledge R. G., Seguin A. (2000) Induction of chalcone synthase expression in white spruce by wounding and jasmonate. *Plant Cell Physiol.* 41, 982–987.
- Rocholl M., Talke-Messerer C., Kaiser T., Batschauer A. (1994) Unit I of the mustard chalcone synthase promoter is sufficient to mediate light responses from different photoreceptors. *Plant Sci.* 97, 189–198.
- Roessner U., Luedemann A., Brust D., Fiehn O., Linke T., Willmitzer L., Fernie A.R. (2001) Metabolic profiling and phenotyping of genetically and environmentally modified plant systems. *Plant Cell* 13, 11-29.
- Roessner U., Wagner C., Kopka J., Trethewey R.N., Willmitzer L. (2000) Simultaneous analysis of metabolites in potato tuber by gas chromatography-mass spectrometry. *Plant J.* 23, 131-142.
- Rohde A., Morreel K., Ralph J. (2004) Molecular phenotyping of the pal1 and pal2 mutants of *Arabidopsis thaliana* reveals far-reaching consequences on phenylpropanoid, amino acid, and carbohydrate metabolism. *Plant Cell* 16, 2749–2771.
- Rolland F., Moore B., Sheen J. (2002) Sugar sensing and signalling in plants. *The Plant Cell* 14, S185–S205.[
- Ryals J.A., Neuenschwander U.H., Willits M.G., Molina A., Steiner H.Y., Hunt M.D. (1996) Systemic acquired resistance, *Plant Cell* 8, 1809-1819.
- Ryan C. (1990) Protease inhibitors in plants: genes for improving defenses against insects and pathogens. *Annu. Rev. Phytopathol.* 28, 425–449.

## References

---

- Ryder T.B., Hedrick S.A., Bell J.N., Liang X., Clouse S. D., Lamb C.J. (1987) Organization and differential activation of a gene family encoding the plant defense enzyme chalcone synthase in *Phaseolus vulgaris*. Mol. Gen. Genet. 210, 219–233.
- Ryder T.B., Cramer C.L., Bell J.N., Robbins M.P., Dixon R.A., Lamb C.J. (1984) Elicitor rapidly induces chalcone synthase mRNA in *Phaseolus vulgaris* cells at the onset of the phytoalexin defense response. Proc. Natl. Acad. Sci. USA 81, 5724–5728.
- Sablowski R., Moyano E., Culianez-Macia F., Schuch W., Martin C., Bevan M. (1994) A flower-specific Myb protein activates transcription of phenylpropanoid synthetic genes. EMBO J. 13, 128–137.
- Sakuta M. (2000) Transcriptional control of chalcone synthase by environmental stimuli. J. Plant Res. 113, 327–333.
- Sambrook J., Fritsch E.F., Maniatis T. (1989) Molecular Cloning: A Laboratory Manual, 2nd ed. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY.
- Sanchez I.J.F. (2008) Polyketide synthase in *Cannabis sativa* L., PhD thesis, Leiden University, Leiden, The Netherlands.
- Sankawa U., Hakamatsuka T. (1997) Biosynthesis of isoflavone and related compounds in tissue cultures of *Pueraria lobata*, p . 25-48 . In K . Ogura and U . Sankawa (ed.), Dynamic aspects of natural products chemistry . Kodansha, Tokyo, Japan.
- Saslawsky D., Winkel S.B. (2001) Localization of flavonoid enzymes in *Arabidopsis* roots. Plant J. 27, 37-48
- Schäfer E., Kunkel T., Frohnmyer H. (1997) Signal transduction in the photocontrol of chalcone synthase gene expression. Plant Cell Environ. 20, 722–727.
- Schenk P.M., Kazan K., Wilson I., Anderson J.P., Richmond T., Somerville S.C., Manners J.M. (2000) Coordinated plant defense responses in *Arabidopsis* revealed by microarray analysis. Proc. Natl. Acad. Sci. USA 97, 11655–11660.
- Schmelzer E., Jähnen W., Hahlbrock K. (1988) *In situ* localization of light-induced chalcone synthase mRNA, chalcone synthase, and flavonoid end products in epidermal cells of parsley leaves. Proc. Natl. Acad. Sci. USA 85, 2989-2993.

- Schmittgen T.D., Zakrajsek B.A., Mills A.G., Gorn V., Singer M.J., Reed M.W. (2000) Quantitative reverse transcription polymerase chain reaction to study mRNA decay: Comparison of endpoint and real-time methods. *Anal. Biochem.* 285, 194-204.
- Schnitzler J.P., Jungblut T.P., Heller W., Hutzler P., Heinzmann U., Schmelzer E., Ernst D., Langebartels C., Sandermann H. (1996) Tissue localisation of UV-B screening pigments and chalcone synthase mRNA in Scots pine (*Pinus sylvestris* L.) needles. *New Phytol.* 132, 247-258.
- Schröder J. (2008) [http://www.biologie.unifreiburg.de/data/bio2/schroeder/CHS\\_Reaction\\_Mechanism.html](http://www.biologie.unifreiburg.de/data/bio2/schroeder/CHS_Reaction_Mechanism.html)
- Schröder J. (1997) A family of plant - specific polyketide synthases: facts and predictions. *Trends Plant Sci.* 2, 373–378.
- Schröder J., Schäfer E. (1980) Radioiodinated antibodies, a tool in studies on the presence and role of inactive enzyme forms: regulation of chalcone synthase in parsley cell suspension cultures. *Arch. Biochem. Biophys.* 203, 800-808.
- Schulze L.P., Becker A.M., Schulz W., Hahlbrock K., Dangl J.L. (1989) Functional architecture of the light-responsive chalcone synthase promoter from parsley. *Plant Cell* 1, 707-714.
- Schuez R., Heller W., Hahlbrock K. (1983) Substrate specificity of chalcone synthase from *Petroselinum hortense*. *J. Biol. Chem.* 258, 6730–6734.
- Seikel M.K., Bushnell A.J., Birzgalis R. (1962) The flavonoid constituents of Barley (*Hordeum vulgare*). III. Lutonarin and its 3'-methyl ether. *Arch. Biochem. Biophys.* 99, 451–457.
- Seki H., Ichinose Y., Ito M., Shiraishi T., Yamada T. (1997) Combined effects of multiple cis-acting elements in elicitor-mediated activation of *PSCHS1* gene. *Plant Cell Physiol.* 38, 96-100.
- Seki H., Nagasugi Y., Shiraishi T., Yamada T. (1999) Changes in vivo DNA-protein interactions in pea phenylalanine ammonia-lyase and chalcone synthase gene promoter induced by fungal signal molecules. *Plant Cell Physiol.* 40, 88-95.
- Shimada H, Kondo K, Fraser P D, Miura Y, Saito T, Misawa N (1998) Increased carotenoid production by the food yeast *Candida utilis* through metabolic

## References

---

- engineering of the isoprenoid pathway. *Appl. Environ. Microbiol.* 64, 2676, 2676–2680.
- Shimizu T., Akada S., Senda M., Ishikawa R., Harada T., Niizeki M., Dube S.K. (1999) Enhanced expression and differential inducibility of soybean chalcone synthase genes by supplemental UV-B in dark-grown seedlings. *Plant Mol. Biol.* 39, 785–795.
- Shvarts M., Borochov A., Weiss D. (1997) Low temperature enhances petunia flower pigmentation and induces chalcone synthase gene expression. *Physiol. Plant.* 99, 67 - 72.
- Smirnoff N. (1998). Plant resistance to environmental stress. *Curr. Opinion Biotechnol.* 9, 214-219.
- Snyder B.A., Nicholson R.L. (1990) Synthesis of phytoalexins in sorghum as a site specific response to fungal ingress. *Science* 248, 1637-1639.
- Soylu S. (2006) Accumulation of cell-wall bound phenolic compounds and phytoalexin in *Arabidopsis thaliana* leaves following inoculation with pathovars of *Pseudomonas syringae*. *Plant. Sci.* 170, 942-952.
- Srivastava V., Anderson O.D., Ow D.W. (1999) Single-copy transgenic wheat generated through the resolution of complex integration patterns. *Proc. Natl. Acad. Sci. USA* 96, 11117–11121.
- Stafford H.A. (1974) Possible multi-enzyme complexes regulating the formation of C<sub>6</sub>-C<sub>3</sub> phenolic compounds and lignins in higher plants. *Rec. Adv. Phytochem.* 8, 53-79.
- Stafford H.A. (1991) Flavonoid evolution: an enzymic approach. *Plant Physiol.* 96, 680-685.
- Staiger D., Kaulen H., Schell J. (1989) A CACGTG motif of the *Antirrhinum majus* chalcone synthase promoter is recognised by an evolutionary conserved nuclear protein. *Proc. Natl. Acad. Sci. USA* 86, 6930–6934.
- Stassi D.L., Kakavas S.J., Reynolds K.A., Gunawardana G., Swanson S., Zeidner D., Jackson M., Liu H., Buko A., Katz L. (1998). Ethyl-substituted erythromycin derivatives produced by directed metabolic engineering. *Proc. Natl. Acad. Sci. USA*. 95, 7305-7309.

- Stephanopoulos G. (1999) Metabolic fluxes and metabolic engineering. *Metab. Eng.* 1, 1-11.
- Sticher L., Mauch-Mani B., Métraux J.P. (1997) Systemic acquired resistance, *Annu. Rev. Phytopathol.* 35, 235-270.
- Stobiecki M., Kachlicki P. (2005). Metabolomics and metabolite profiling – can we achieve the goal? *Acta Physiol. Plant.* 27, 109–116.
- Strid A., Porra R.J. (1992) Alterations in pigment content in leaves of *Pisuvn sativum* after exposure to supplementary UV-B. *Plant Cell Physiol.* 33, 1015-1023.
- Sullivan M.L. (2009) A Novel red clover hydroxycinnamoyl transferase has enzymatic activities consistent with a role in phasic acid (2-O-[cafeoyl]-L-malate) biosynthesis. *Plant Physiol.* 150, 1866–1879.
- Sumner L.W., Mendes P., Dixon R.A. (2003) Plant metabolomics: large-scale phytochemistry in the functional genomics era. *Phytochemistry* 62, 817–836.
- Taylor L.P., Briggs W.R. (1990) Genetic regulation and photocontrol of anthocyanin accumulation in maize seedlings. *Plant Cell* 2, 115-127.
- Taylor R.M., Tobin A.K., Bray C.M. (1997) DNA damage and repair in plants. In PJ Lumsden, ed, *Plants and UV-B*. Cambridge University Press, Cambridge, UK, 53-75.
- Terzaghi W.B., Cashmore A.R. (1995). Light-regulated transcription. *Annu. Rev. Plant Physiol. Plant Mol. Biol.* 46, 445–474.
- Tevini M., Braun J., Fieser G. (1991) The protective function of the epidermal layer of rye seedlings against ultraviolet-B radiation. *Photochem. Photobiol.* 53, 329-333.
- Thain S.C., Murtas G., Lynn J.R., McGrath R.B., Millar A.J. (2002) The circadian clock that controls gene expression in *Arabidopsis* is tissue specific. *Plant Physiol.* 130, 102–110.
- Tian L., Wan S.B., Pan Q.H., Zheng Y.J., Huang W.D. (2008) A novel plastid localization of chalcone synthase in developing grape berry. *Plant Sci.* doi: 10.1016/j.plantsci.2008.03.012.
- Tropf S., Kärcher B., Schröder G., Schröder J. (1995) Reaction mechanisms of homodimeric plant polyketide synthase (stilbenes and chalcone synthase). A single active site for the condensing reaction is sufficient for synthesis of

## References

---

- stilbenes, chalcones, and 6'-deoxychalcones. *J. Biol. Chem.* 270(14), 7922–7928.
- Tropf S., Lanz T., Rensing S.A., Schröder J., Schröder G. (1994) Evidence that stilbene synthases have developed from chalcone synthases several times in the course of evolution. *J. Mol. Evol.* 38, 610-618.
- Tsukaya H., Ohshima T., Naito S., Chino M., Komeda Y. (1991). Sugar-dependent expression of the *CHS-A* gene for chalcone synthase from petunia in transgenic *Arabidopsis*. *Plant Physiol.* 97, 1414-1421.
- Tuteja J.H., Clough S.J., Chan W.C., Vodkin L.O. (2004) Tissue-specific gene silencing mediated by a naturally occurring chalcone synthase gene cluster in *Glycine max*. *Plant Cell* 16, 819–835.
- Tzfira T., Citovsky V. (2006) *Agrobacterium*-mediated genetic transformation of plants: biology and biotechnology. *Curr. Opin. Biotechnol.* 17, 147–154.
- Uknes S., Winter A.M., Delaney T., Vernooij B., Morse A., Friedrich L., Nye Potter G., Ward E., Ryals J. (1993) Biological induction of systemic acquired resistance in *Arabidopsis*, *Mol. Plant-Microbe Interact.* 6, 692-698.
- Van der Krol A.R., Mur L.A., Beld M., MoI J.N.M., Stuitje A.R. (1990a). Flavonoid genes in petunia: Addition of a limited number of gene copies may lead to a suppression of gene expression. *Plant Cell* 2, 291-299.
- Van der Krol A.R., Mur L.A., de Lange P., Gerats A.G.M., MOI J.N.M., Stuitje A.R. (1990b). Antisense chalcone synthase genes in petunia: Visualization of variable of transgene expression. *Mol. Gen. Genet.* 220, 204-212.
- Van der Krol AR., Lenting P.E., Veenstra J., van der Meer I.M., Koes R.E., Gerats A.G.M., MOI, J.N.M., and Stuitje, A.R. (1988). An anti-sense chalcone synthase gene in transgenic plants inhibits flower pigmentation. *Nature* 333, 866-869.
- Van der Meer I.M., Stuitje A.R., Mol J.N.M. (1993) Regulation of general phenylpropanoid and flavonoid gene expression. In *Control of Plant Gene Expression*. Edited by Verma, D.P.S. pp. 125–155. CRC Press, Boca Raton.
- Van der Meer I.M., Spelt C.E., Mol J.N.M., Stuitje A.R (1990) Promoter analysis of the chalcone synthase (*chsA*) gene of Petunia hybrida: A 67 bp promoter region directs flower-specific expression. *Plant Mol. Biol.* 15, 95–109.

- Van Etten H.D., Pueppke S.G. (1976) Isoflavonoid phytoalexins, pp. 239–289, *in* J. Friend and D.R. Threlfall (eds.). Biochemical Aspects of Plant-Parasite Relationships. Academic Press, New York.
- Van Tunen A.J., Koes R.E., Spelt C.E., van der Krol A.R., Stuitje A.R., Mol J.N.M. (1988). Cloning of the two chalcone flavanone isomerase genes from *Petunia hybrida*: Coordinate, light-regulated, and differential expression of flavonoid genes. *EMBO J.* 7, 1257-1263.
- Vaucheret H., Béclin C., Elmayan T., Feuerbach F., Godon C., Morel J.B., Mourrain P., Palauqui J.C., Vernhettes S. (1998) Transgene-induced gene silencing in plants. *Plant J.* 16, 651-659.
- Veit M., Pauli G.F. (1999) Major flavonoids from *Arabidopsis thaliana* leaves. *J. Nat. Prod.* 62, 1301–1303.
- Verhoeven M.E., Bovy A., Collins G., Muir S., Robinson S., de Vos C.H.R., Colliver S. (2002) Increasing antioxidant levels in tomatoes through modification of the flavonoid biosynthetic pathway. *J. Exp. Bot.* 53, 2099–2106.
- Verpoorte R., Choi Y.H., Kim H.K. (2007) NMR-based metabolomics at work in phytochemistry, *Phytochem. Rev.* 6, 3-14.
- Verpoorte R., Van der Heijden R., Memelink J. (2000) Engineering the plant cell factory for secondary metabolite production. *Transgenic Res.* 9, 323-343.
- Vleeshouwers V.G.A.A., van Dooijeweert W., Govers F., Kamoun S., Colon L.T. (2000) Does basal *PR* gene expression in *Solanum* species contribute to non-specific resistance to *Phytophthora infestans*?, *Physiol. Mol. Plant Pathol.* 57, 35-42.
- Von Roepenack L.E., Degenkolb T., Zerjeski M., Franz M., Roth U., Wessjohann L., Schmidt J., Scheel D., Clemens S. (2004) Profiling of *Arabidopsis* secondary metabolites by capillary liquid chromatography coupled to electrospray ionization quadrupole time-of-flight mass spectrometry. *Plant Physiol* 134, 548–559.
- Wade H.K., Bibikova T.N., Valentine W.J., Jenkins G.I. (2001) Interactions within a network of phytochrome, cryptochrome and UV-B phototransduction pathways regulate chalcone synthase gene expression in *Arabidopsis* leaf tissue. *Plant J.* 25, 675–685.

## References

---

- Wagner C., Sefkow M., Kopka J. (2003) Construction and application of a mass spectral and retention time index database generated from plant GC/EI-TOF-MS metabolite profiles. *Phytochemistry* 62, 887–900.
- Wang C.K., Chen P.Y., Wang H.M., To K.Y. (2006) Cosuppression of tobacco chalcone synthase using *Petunia* chalcone synthase construct results in white flowers. *Botanical Studies* 47, 71-82.
- Wasternack C., Parthier B. (1997) Jasmonate-signalled plant gene expression. *Trends Plant Sci.* 2, 302–307.
- Wegulo S. N., Yang X. B., Martinson C. A., Murphy P. A. (2005) Effects of wounding and inoculation with *Sclerotinia sclerotiorum* on isoflavones concentrations in soybean. *Canadian J. plant sci.* 85, 749-760.
- Weiergang I., Hipskind J.D., Nicholson R.L. (1996) Synthesis of 3-deoxyanthocyanidin phytoalexins in sorghum occurs independent of light. *Physiol. Mol. Plant Pathol.* 49, 377-388.
- Weisshaar B., G . Jenkins I . (1998) . Phenylpropanoid biosynthesis and its regulation. *Curr . Opin . Plant Biol .* 1, 251-257.
- Weisshaar B., Armstrong G.A., Block A., da Costa e Silva O., Hahlbrock K. (1991) Light inducible and constitutively expressed DNAbinding proteins recognising a plant promoter element with functional relevance in light responsiveness. *EMBO J.* 10, 1777-1786.
- Wendehenne D., Durner J., Chen Z., Klessig D. F. (1998) Benzothiadiazole, an inducer of plant defenses, inhibits catalase and ascorbate peroxidase. *Phytochemistry* 47, 651-657.
- Whitehead J.M., Dixon R.A. (1983) Chalcone synthase from cell suspension cultures of *Phaseolus vulgaris*. *Biochem. Biophys. Acta.* 747, 298-303.
- Williams M.E., Foster R., Chua N.H. (1992) Sequences flanking the hexameric G-box core CACGTG affects the specificity of protein binding. *Plant Cell* 4, 485-496.
- Winer J., Jung C.K.S., Shackel I., Williams P.M. (1999) Development and validation of real-time quantitative reverse transcriptase-polymerase chain reaction for monitoring gene expression in cardiac myocytes in vitro, *Anal. Biochem.* 270, 41-49.

- Winer J., Jung C.K.S., Shackel I., Williams P.M. (1999) Development and Validation of Real-Time Quantitative Reverse Transcriptase–Polymerase Chain Reaction for Monitoring Gene Expression in Cardiac Myocytes in Vitro. *Anal. Biochem.* 270, 41-49.
- Wingender R., Röhrlig H., Höricke C., Wing D., Schell J. (1989) Differential regulation of soybean chalcone synthase genes in plant defense, symbiosis and upon environmental stimuli. *Mol. Gen. Genet.* 218, 315–322.
- Winkel S.B. (2004) Metabolic channeling in plants. *Annu. Rev. Plant Biol.* 55, 85 –107.
- Winkel S.B. (2002) Biosynthesis of flavonoids and effects of stress. *Curr. Opinion in Plant Biol.* 5 (3), 218-223.
- Winkel S.B. (2001) Flavonoid biosynthesis: a colorful model for genetics, biochemistry, cell biology and bio technology. *Plant Physiol.* 126, 485–493.
- Winkel S.B. (1999) Evidence for enzyme complexes in the phenylpropanoid and flavonoid pathways. *Physiol. Plant* 107, 142–149.
- Wollenweber E., Dietz V.H. (1981) Occurrence and distribution of free flavonoid aglycones in plants. *Phytochemistry* 20, 869-932.
- Wrolstad R.E. (2000) Anthocyanins. In: F.J. Francis and G.J. Lauro, Editors, *Natural Food Colorants*, Marcel Dekker, New York pp. 237–252.
- Xu B.W., Wild J.R., Kenerley C.M. (1996) Enhanced expression of a bacterial gene for pesticide degradation in a common soil fungus. *J. Ferment. Bioeng.* 81, 473-481.
- Xu Y., Chang P.F.L., Liu D., Narasimhan M.L., Raghothama K.G., Hasegawa P.M., Bressan R.A. (1994) Plant defence genes are synergistically induced by ethylene and methyl jasmonate. *Plant cell* 6, 1077-1085.
- Yamaguchi T., Kurosaki F .F., Suh D . D. Y ., Sankawa U ., Nishioka M ., Akiyama T ., Shibuya, M ., Ebizuka Y . (1999 ) Cross-reaction of chalcone synthase and stilbene synthase overexpressed in *E . coli* . *FEBS Lett.* 460, 457-461.
- Yang W.C., Canter C.H.C. J., Hogendijk P., Katinakis P., Wijffelman C.A., Franssen H., van Kammen A., Bisseling T. (1992) *In-situ* localization of chalcone synthase mRNA in pea root nodule development. *Plant J.* 2, 143-152.

## References

---

- Yilmaz Y., R. T. Toledo (2004) Major flavonoids in grape seeds and skins: Antioxidant capacity of catechin, epicatechin, and gallic acid. *J. Agric. Food Chem.* 52, 255–260.
- Yoshida K., Wakamatsu S., Sakuta M. (2008) Characterization of SBZ1, a soybean bZIP protein that binds to the chalcone synthase gene promoter. *Plant Biotechnol.* 25, 131–140.
- Yu L.M., Lamb C.J., Dixon R.A. (1993) Purification and biochemical characterization of proteins which bind to the H-box *cis*-element implicated in transcriptional activation of plant defense genes. *Plant J.* 3, 805–816.
- Yuan J.S., Burris J., Stewart N.R. (2007) Mentewab A., Stewart C.N. Jr., Statistical tools for transgene copy number estimation based on real-time PCR. *BMC Bioinformatics*, 8(7), S6.
- Zabala G., Zou J.J., Tuteja J., Gonzalez D.O., Clough S.J., Vodkin L.O. (2006) Transcriptome changes in the phenylpropanoid pathway of *Glycine max* in response to *Pseudomonas syringae* infection. *BMC Plant Biol.* 6: 26.
- Zeier J., Delledonne M., Mishima T., Severi E., Sonoda M., Lamb C. (2004) Genetic elucidation of nitric oxide signaling in incompatible plant-pathogen interactions. *Plant Physiol.* 136, 2875–2886.
- Zhou B., Li Y., Xu Z., Yan H., Homma S. and Kawabata S. (2007) Ultraviolet A-specific induction of anthocyanin biosynthesis in the swollen hypocotyls of turnip (*Brassica rapa*). *J. Exp. Bot.* doi:10.1093/jxb/erm036
- Zhu Q., Dröge L.W., Dixon R.A., Lamb C. (1996) Transcriptional activation of plant defense genes. *Curr. Opin. Genet. Dev.* 6, 624–630.
- Zufall R., Rausher M.D. (2001) Diffuse coevolution and anthocyanin production. *Botany 2001: "Plants and People"*, Albuquerque, New Mexico.
- Zuurbier K.W.M., Lesser J., Berger T., Hofte A.J.P., Schröder G., Verpoorte R., Schröder J. (1998) 4-hydroxy-2- pyrone formation by chalcone synthase and styrene synthase with nonphysiological substrates. *Phytochemistry* 49,1945-1951.
- Zuurbier K.W.M., Fung S.Y., Scheffer J.J.C., Verpoorte R. (1995) Formation of aromatic intermediates in the biosynthesis of bitter acids in *Humulus lupulus*. *Phytochemistry* 38, 77-82.

- Zuurbier K.W.M., Fung S.Y., Scheffer J.J.C., Verpoorte R. (1993) Assay of chalcone synthase activity by high-performance liquid chromatography. *Phytochemistry* 34, 1225-1229.
- Zwaagstra M.E., Timmerman H., Tamura M., Tohma T., Wada Y., Onogi K., Zhang M.Q. (1997) Synthesis and Structure-Activity Relationships of Carboxylated Chalcones: A Novel Series of *CysLT<sub>1</sub>* (LTD<sub>4</sub>) Receptor Antagonists. *J. Med. Chem.* 40, 1075-1089.

## **Curriculum vitae**

The author of this thesis, Thi Thanh Hien Dao (30/01/1976), was born and grew up in Hanoi, Vietnam - the country of rice fields. In 1992, she completed her higher education from the Hanoi-Amsterdam high school, Hanoi, Vietnam and continued her studies at the Hanoi University of Pharmacy. She obtained her pharmacist diploma in 1997 and master degree in 2000 at the same university. From 2000 to 2004 she worked as lecturer in the Traditional Pharmacy Department at Hanoi University of Pharmacy. In 2004 she started her PhD program at the Division of Pharmacognosy, Section Metabolomics, Institute of Biology Leiden with a fellowship of the Vietnamese Oversea Scholarship Program. In 2009 she completed her PhD project under supervision of Prof. Dr. Rob Verpoorte.

## List of publications

1. Thi Thanh Hien Dao, Roberto Chacon Puig, Hye Kyong Kim, Cornelis Erkelens, Alfons W.M. Lefeber, Huub J.M. Linthorst, Young Hae Choi, Robert Verpoorte, **Effect of benzothiadiazole on the metabolome of *Arabidopsis thaliana*.** Plant Physiology and Biochemistry, Volume 47, Issue 2, February 2009, Pages 146-152.
2. Thi Thanh Hien Dao, Huub J.M. Linthorst, Robert Verpoorte, **Chalcone synthase and its functions in plant resistance: A review.** Phytochemistry reviews (submitted)
3. Thi Thanh Hien Dao, Huub J.M. Linthorst, Hye Kyong Kim, Young Hae Choi, Robert Verpoorte, **The metabolic changes in *Arabidopsis thaliana* under UV/blue light** (in preparation)

## Acknowledgements

Though only my name appears on the cover of this thesis, a great many people have contributed to its production.

My advisor, Prof. Dr. Rob Verpoorte, gave me the freedom to explore on my own and at the same time the guidance to recover when my steps faltered. Rob taught me how to question thoughts and express ideas. His patience and support helped me to overcome many crisis situations and finish this thesis.

I would also like to mention my co-advisor, Dr. Huub Linthorst. He introduced me to Molecular Biology and his teaching inspired me to work successfully in this, for me, new and interesting field.

This work could not have been done without help of Dr. Hye Kyong Kim and Dr. Young Hae Choi, who taught and helped me a lot in my experimental work as well as in writing scientific papers. Also I like to acknowledge the help of Marianne for the Samenvatting and of Anneke to settle in the Netherlands.

All the members of the Division of Pharmacognosy, section Metabolomic, Institute of Biology, Leiden University have been great colleagues during my graduate studies.

Most importantly, none of this would have been possible without the love and patience of my family. My family has been a constant source of love, concern, support and strength all these years. I would like to express my heart-felt gratitude to Mai, Khoi, Binh and my parents.

Finally, I appreciate the financial support from VOSP that funded my research described in this thesis.