PLANT RESEARCH INTERNATIONAL

WAGENINGEN UR

Plant enzymes for industrial application

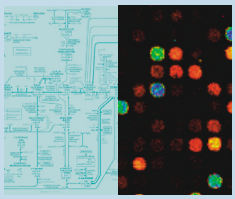
Why plant enzymes?

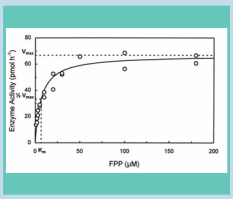
Plants produce diverse sets of *unique* chemical compounds.

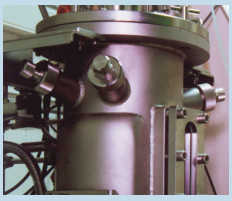
To synthesise these, plants use enzymes that are not present in any other organism.

These enzymes can be deployed for diverse industrial applications.

Plant Kingdom → Source identification → Gene identification → Functional analysis → Industrial manufacturing → Industry







Flavour

Esters, terpenes, norisoprenoids

Neutraceuticals

Flavonoids, amino acids, fructans, carotenoids

Pharma

Glycosylation, botanicals, artemisinin, antibodies, vaccines

Agrochemicals

Fungicides, toxins, insecticides, repellents

Track record: patent applications and high quality peer reviewed journals

Flavour

Aharoni et al., (2000) Identification of the SAAT gene involved in strawberry flavor biogenesis by use of DNA microarrays. **Plant Cell** 12(5): 647-661

Aharoni et al., (2004) Gain and loss of fruit flavor compounds produced by wild and cultivated strawberry species. **Plant Cell** 16(11): 3110-3131

Beekwilder et al., (2004) Functional characterization of enzymes forming volatile esters from strawberry and banana. **Plant Physiol.** 135(4): 1865-1878

de-Kraker et al., (2002) Biosynthesis of costunolide, dihydrocostunolide, and leucodin. Demonstration of cytochrome P450-catalyzed formation of the lactone ring present in sesquiterpene lactones of chicory. **Plant Physiol.** 129(1): 257-268

de-Kraker et al., (2003) Hydroxylation of sesquiterpenes by enzymes from chicory (Cichorium intybus L.) roots. **Tetrahedron** 59(3): 409-418

El-Tamer et al., (2003) The influence of monoterpene synthase transformation on the odour of tobacco. **J. Biotechnology** 106(1): 15-21

Lucker et al., (2002) Monoterpene biosynthesis in lemon (Citrus limon) - cDNA isolation and functional analysis of four monoterpene synthases. **Eur. J. Biochem.** 269(13): 3160-3171

Lucker et al., (2004) Metabolic engineering of monoterpene biosynthesis: two-step production of (+)-trans-isopiperitenol by tobacco. **Plant J.** 39(1): 135-145

A number of **patent** applications have been filed relating to these publications.

Neutraceuticals

Bovy et al., (2002) High-flavonol tomatoes resulting from the heterologous expression of the maize transcription factor genes LC and C1. **Plant Cell** 14(10): 2509-2526

Femia et al., (2003) Effect of diets fortified with tomatoes or onions with variable quercetin-glycoside content on azoxymethane-induced aberrant crypt foci in the colon of rats. **Eur. J. Nutr.** 42(6): 346-352

Helsper et al., (2002) Quadrupole time-of-flight mass spectrometry: A method to study the actual expression of allergen isoforms identified by PCR cloning. **J. Allergy Clin. Immun.** 110(1): 131-138

Muir et al., (2001) Overexpression of petunia chalcone isomerase in tomato results in fruit containing increased levels of flavonols. **Nature Biotechnol.** 19(5): 470-474

Sevenier et al., (1998) High level fructan accumulation in a transgenic sugar beet. **Nature Biotechnol.** 16(9): 843-846

Sevenier et al., (2002) Increased production of nutriments by genetically engineered crops. **J. Am. Coll. Nutr.** 21(3): 199S-204S

van-der-Meer et al., (2001) Plant-based raw material: improved food quality for better nutrition via plant genomics. **Curr. Op. Biotechnol.** 2 (5): 488-492

Van-der-Meer et al., (1998) Cloning of the fructan biosynthesis pathway of Jerusalem artichoke. **Plant J.** 15 (4): 489-500

Verhoeyen et al., (2002) Increasing antioxidant levels in tomatoes through modification of the flavonoid biosynthetic pathway. **J. Exp. Bot.** 53(377): 2099-2106

A number of **patent** applications have been filed relating to these publications.

Pharma

Bakker et al., (2001) Galactose-extended glycans of antibodies produced by transgenic plants. **Proc. Natl. Acad. Sci. U S A.** 98 (5) : 2899-2904

Bakker et al., (2001) Plant members of the a 1->3/4-fucosyltransferase gene family encode an a 1->4-fucosyltransferase, potentially involved in Lewis(a) biosynthesis, and two core a 1->3-fucosyltransferases. **FEBS-lett.** 507 (3) : 307-312

Bakker et al., (1999) An Arabidopsis thaliana cDNA complements the N-acetylglucosaminyl transferase I deficiency of CHO Lec1 cells. **Biochem. Biophys. Res. Comm.** 261 (3) : 829-832

Beekwilder et al., (1999) A phagemid vector using the E. coli phage shock promoter facilitates phage display of toxic proteins. **Gene** 228: 23-31

Bino et al., (2004) Potential of metabolomics as a functional genomics tool. **Trends Plant Sci.** 9(9):418-25.

Bouwmeester et al., (1999) Amorpha-4,11-diene synthase catalyses the first probable step in artemisinin biosynthesis. **Phytochem.** 52 (5) : 843-854

Bouwmeester et al., (2002) Isolation and characterization of two germacrene A synthase cDNA clones from chicory. **Plant Physiol.** 129 (1) : 134-144

de-Kraker et al., (2001) Germacrenes from fresh costus roots. **Phytochem.** 58 (3) : 481-487

Ceci et al., (2003) Selection by phage display of a mustard chymotrypsin inhibitor toxic to pea aphid. **Plant J.** 33: 557-566

Galesa et al., (2003) Structural characterization of thyroglobulin type-1 domains of equistatin. **FEBS Lett.** 539:120-124

Lauterslager et al., (2001) Oral immunisation of naive and primed animals with transgenic potato tubers expressing LT-B. **Vaccine** 19 (17-19) 2749-2755

Outchkourov et al., (2002) Optimization of the expression of equistatin in Pichia pastoris. **Prot. Expr. Purif.** 24:18-24

Rogelj et al., (2000) Expression, purification and characterisation of equistatin in Pichia pastoris. **Prot. Express. Purif.** 19: 329-334

Schmidt et al., (1999) Mechanisms of the biosynthesis of sesquiterpene enantiomers (+)- and (-)-germacrene D in Solidago canadensis. **Chirality** 11 (5-6) : 353-362

A number of **patent** applications have been filed relating to these publications.

Agrochemicals

Aharoni et al., (2003) Terpenoid metabolism in wild-type and transgenic Arabidopsis plants. **Plant Cell** 15(12): 2866-2884

Balkema-Boomstra et al., (2003) Role of cucurbitacin C in resistance to spider mite (Tetranychus urticae) in cucumber (Cucumis sativus L.). **J. Chem. Ecol.** 29(1): 225-235

Bouwmeester et al., (2004) Biosynthesis of the monoterpenes limonene and carvone in the fruit of caraway - I. Demonstration of enzyme activities and their changes with development. **Plant Physiol.** 117(3): 901-912

Duetz et al., (2003) Biotransformation of limonene by bacteria, fungi, yeasts and plants. **Appl. Microbiol. Biotechnol.** 61: 269-277

Estebanez-Perpina-E et al., (2001) Crystal structure of a novel mid-gut procarboxypeptidase from the cotton pest Helicoverpa armigera. **J. Mol. Biol.** 313(3): 629-638

Jongsma et al., (1995) Adaptation of Spodoptera exigua larvae to plant proteinase inhibitors by induction of gut proteinase activity insensitive to inhibition. **Proc. Natl. Acad. Sci. U S A.** 92(17): 8041-5.

Lucker et al., (2001) Expression of Clarkia S-linalool synthase in transgenic petunia plants results in the accumulation of S-linalyl-beta-D-glucopyranoside. **Plant J.** 27(4): 315-324

Volpicella et al., (2003) Properties of purified gut trypsin from Helicoverpa zea, adapted to proteinase inhibitors. **Eur. J. Biochem.** 270(1): 10-19

A number of **patent** applications have been filed relating to these publications.

Plant Research International B.V.

P.O. Box 16, 6700 AA Wageningen, The Netherlands

Tel: +31 317 47 71 64 - Fax: +31 317 41 80 94

E-mail: jules.beekwilder@wur.nl