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NMR spectroscopy and chemometrics-based analysis of grapevine

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References

References

- Abdel-Farid IB, Jahangir M, van del Hondel CAMJJ, Kim HK, Choi YH, Verpoorte R (2009) Fungal infection induced metabolites in *Brassica rapa*. *Plant Sci* 176:608-615.
- Abreu SDM, Caboni P, Cabras P, Alves A, Garau VL (2006) A comparison of a gas chromatographic with electron-capture detection and a gas chromatographic with mass spectrometric detection screening methods for the analysis of famoxadone in grapes and wines. *J Chromatogr A* 1103:362-367.
- Abreu SDM, Caboni P, Cabras P, Garau VL, Alves A (2006) Validation and global uncertainty of a liquid chromatographic with diode array detection method for the screening of azoxystrobin, kresoxim-methyl, trifloxystrobin, famoxadone, pyraclostrobin and fenamidone in grapes and wine. *Anal Chim Acta* 573:291-297.
- Adrian M, Jeandet P, Bessis R, Joubert JM (1996) Induction of phytoalexin (Resveratrol) synthesis in Grapevine leaves treated with aluminum chloride (AlCl₃). *J Agric Food Chem* 44:1979-1981.
- Adrian M, Jeandet P, Veneau J, Weston LA, Bessis R (1997) Biological activity of resveratrol, a stilbenic compound from grapevines, against *Botrytis cinerea*, the causal agent for gray mold. *J Chem Ecol* 23:1689-1702.
- Adrian M, Jeandet P, Breuil AC, Levite D, Debord S, Bessis R (2000) Assay of resveratrol and derivative stilbenes in wines by direct injection high performance liquid chromatography. *Am J Enol Viticult* 51:37-41.
- Aharoni A, de Vos CHR, Verhoeven HA, Maliepaard CA, Kruppa G, Bino RJ, Goodenowe DB (2002) Non-targeted metabolome analysis by use of Fourier Transform Ion Cyclotron Mass Spectrometry. *OMICS* 6:217-34.
- Ait-Barka E, Eullaffroy P, Clement C, Vernet G (2004) Chitosan improves development, and protects *Vitis vinifera* L. against *Botrytis cinerea*. *Plant Cell Rep* 22:608-614.
- Alcalde-Eon C, Escribano-Bailon MT, Santos-Buelga C, Rivas Gonzalo JC (2006) Changes in the detailed pigment composition of red wine maturity and ageing- A comprehensive study. *Anal Chem Acta* 563:238-254.
- Ali K, Maltese F, Choi YH, Verpoorte R (2010) Metabolic constituents of grapevine and grape-derived products. *Phytochem Rev* 9:357-378.
- Ali K, Maltese F, Fortes AM, Pais MS, Choi YH, Verpoorte R (2011) Monitoring biochemical changes during grape berry development in Portuguese cultivars by NMR spectroscopy. *Food Chem* 124:1760-1769.
- Ali K, Maltese F, Zyprian E, Rex M, Choi YH, Verpoorte R (2009) NMR metabolic fingerprinting based identification of grapevine metabolites associated with downy mildew resistance. *J Agric Food Chem* 57:9599-9606.
- Allwood JW, Goodacre R (2010) An introduction to liquid chromatography-mass spectrometry instrumentation applied in plant metabolomic analyses. *Phytochem Anal* 21:33-47.
- Amaral FM, Caro MSB (2005) Investigation of different pre-concentration methods for NMR analyses of Brazilian white wine. *Food Chem* 93:507-510.
- Amella AL, Bronner C, Briancon F, Haag M, Anton R, Landry Y (1985) Inhibition of mast cell histamine release by flavonoids and bioflavonoids. *Planta Med* 51:16-21.
- Anastasiadi M, Zira A, Magiatis P, Haroutounian SA, Skaltsounis AL, Mikros E (2009) ¹H NMR-based metabolomics for the classification of Greek wines according to variety, region, and vintage. Comparison with HPLC data. *J Agric Food Chem* 57:11067-11074.
- Asenstorfer RE, Markides AJ, Iland PG, Jones GP (2003) Formation of vitisin A during red wine vinification and maturation. *Aust J Grape Wine Res* 9:40-46.
- Aziz A, Pionssot B, Daire X, Adrian M, Bezier A, Lambert B, Joubert JM, Pugin A (2003) Laminarin elicits defense responses in grapevine and induces protection against *Botrytis cinerea* and *Plasmopara viticola*. *Mol Plant Microbe-Interact* 16:1118-1128.
- Aziz A, Heyraud A, Lambert B (2004) Oligogalacturonide signal transduction, induction of defense-related responses and protection of grapevine against *Botrytis cinerea*. *Planta* 218:767-774.
- Aznar M, Arroyo T (2007) Analysis of wine volatile profile by purge-and-trap-gas chromatography-mass spectrometry. Application to the analysis of red and white wines from different Spanish regions. *J Chromatogr A* 1165:151-157.
- Baderschneider B, Winterhalter P (2000) Isolation and characterization of novel Stilbene derivative from Reisling wine. *J Agric Food Chem* 48:2681-2686.
- Baderschneider B, Winterhalter P (2001) Isolation and characterization of novel Benzoates, Cinnamates, Flavonoids, and Liganans from Reisling wine and screening for antioxidant activity. *J Agric Food Chem* 49:2788-2798.
- Bagchi D, Garg A, Krohn R, Bagchi M, Bagchi DJ, Balmoori J, Stohs SJ (1998) Protective effects of grape seed proanthocyanidins and selected antioxidant against TPA-induced hepatic and brain lipid peroxidation and DNA fragmentation, and peritoneal macrophage activation in mice. *Gen Pharmacol* 30:771-776.

- Bailey NJC, Wang Y, Sampson J, Davis W, Whitcombe I, Hylands PJ, Croft SL, Holmes E (2004) Prediction of anti-plasmodial activity of *Artemisia annua* extracts: application of ¹H NMR spectroscopy and chemometrics. *J Pharmaceut Biomed* 35:117-126.
- Baowen Q, Yulin Z, Xin W, Wenjing X, Hao Z, Zhizhi C, Xingmei D, Xia Z, Yuquan W, Lijuan C (2010) A further investigation of concerning correlation between anti-fibrotic effect of liposomal quercetin and inflammatory cytokines in pulmonary fibrosis. *Eur J Pharmacol* 642: 134-139.
- Barlass M, Miller RM, Douglas TJ (1987) Development of methods for screening grapevines for resistance to downy mildew. II. Resveratrol production. *Am J Enol Viticult* 38:65-68.
- Barstad B, Sørensen TI, Tjønneland A, Johansen D, Andersen IB, Grønbaek M (2005) Intake of wine, beer and spirits and risk of gastric cancer. *Eur J Cancer Prev* 14:239-245.
- Basly JP, Marre-Fournier F, Le-Bail JC, Habrioux G, Chulia AJ (2000) Estrogenic/antiestrogenic and scavenging activities of *trans*- and *cis*-resveratrol. *Life Sci* 66:769-777.
- Baur JA, Pearson KJ, Price NL, Jamieson HA, Lerin C, Kalra A, Prabhu VV, Allard JS, Lopez-Lluch G, Lewis K, Pistell PJ, Poosala S, Becker KG, Boss O, Gwinn D, Wang M, Ramaswamy S, Fishbein KW, Spencer RG, Lakatta EG, Le-Couteur D, Shaw RJ, Navas P, Puigserver P, Ingram DK, de Cabo R, Sinclair DA (2006) Resveratrol improves health and survival of mice on a high-calorie diet. *Nature* 444: 337-342.
- Bavaresco L, Cante E, Fregoni M, Trevisan M (1997) Constitutive stilbene contents of grapevine cluster stems as potential source of resveratrol in wine. *Vitis* 36:115-118.
- Beckonert O, Keun HC, Ebbels TM, Bundy JG, Holmes E, Lindon JC, Nicholson JK (2007) Metabolic profiling, metabolomic and metabonomic procedures for NMR spectroscopy of urine, plasma, serum, and tissue extracts. *Nat Protoc* 2:2692-2703.
- Belhadj A, Saigne C, Telef N, Cluzet S, Bouscaut J, Corio-Costet MF, Mearillon JM (2006) Methyl jasmonate induces defense responses in grapevine and triggers protection against *Erysiphe necator*. *J Agric Food Chem* 54:9119-9125.
- Belton PS, Colquhoun IJ, Kemsley EK, Delgadillo I, Roma P, Dennis MJ, Sharman M, Holmes E, Nicholson JK, Spraul M (1998) Application of chemometrics to the ¹H NMR spectra of apple juices: discrimination between apple varieties. *Food Chem* 61:207-213.
- Bennick A (1982) Salivary proline-rich proteins. *Mol Cell Biochem* 45:83-99.
- Berenbaum MR (1995) Turnabout is fair play: Secondary roles for primary compounds. *J Chem Ecol* 21:925-940.
- Bertelli AAE, Migliori M, Filippi C, Gagliano N, Donetti E, Panichi V, Scalori V, Colombo R, Mannari C, Tillement J-P, Giovannini L (2005) Effect of ethanol and red wine on ochratoxin A-induced experimental acute nephrotoxicity. *J Agric Food Chem* 53:6924-6929.
- Bertrand M. (2008) Virgin grape seed oil: Is it really a nutritional highlight? *Eur J Lipid Sci Technol* 110:645-650.
- Bevin CJ, Damberg RG, Fergusson AJ, Cozzolino D (2008) Varietal discrimination of Australian wines by means of mid-infrared spectroscopy and multivariate analysis. *Anal Chim Acta* 621:19-23.
- Bezier A, Lambert B, Baillieux F (2002) Study of defense-related gene expression in grapevines leaves and berries infected with *Botrytis cinerea*. *Eur J Plant Pathol* 108:111-120.
- Bianchi F, Careri M, Corradini C (2005) Novel approach for the rapid determination of water-soluble organic acids in wine by co-electroosmotic flow capillary zone electrophoresis. *J Sep Sci* 28:898-904.
- Bino RJ, de Vos CHR, Lieberman M, Hall, RD, Bovy AG, Jonker HH, Tikunov Y, Lommen A, Levin I (2005) The light hyperresponsive *high pigment-2^{del}* mutation of tomato: alterations in the fruit metabolome. *New Phytol* 166:427-438.
- Bisson LF (1999) Stuck and sluggish fermentation. *Am J Enol Viticult* 50:107-119.
- Björnsdóttir US, Cypcar DM (1999) Asthma: an inflammatory mediator soup. *Allergy* 54:55-61.
- Blateyron L, Sablayrolles JM (2001) Stuck and slow fermentations in enology: Statistical study of causes and effectiveness of combined additions of oxygen and diammonium phosphate. *J Biosci Bioeng* 91:184-189.
- Boido E, Alcalde-Econ C, Carrau F, Dellacassa E, Rivas-Gonzalo JC (2006) Ageing effect on pigment composition and color of *Vitis vinifera* L. cv. Tannat wines. Contribution to the main pigment families to wine color. *J Agric Food Chem* 54:6692-6704.
- Bomser J, Singletary K, Wallig MA, Smith MAL (1999) Inhibition of TPA-induced tumor promotion in CD-1 mouse epidermis by a polyphenolic fraction from grape seeds. *Cancer Lett* 135:151-157.
- Bomser J, Singletary K, Meline B (2000) Inhibition of 12-O-tetradecanoylphorbol-13-acetate (TPA)-induced mouse skin ornithine decarboxylase and protein kinase C by polyphenolics from grapes. *Chem Biol Interact* 127:45-59.

References

- Borbalán ÁMA, Zorro L, Guillén DA, Barroso CG (2003) Study of the polyphenol content of red and white grape varieties by liquid chromatography-mass spectrometry and its relationship to antioxidant power. *J chromatogr A* 1012:31-38.
- Borie B, Jeandet P, Parize A, Bessis R, Adrian M (2004) Resveratrol and stilbene synthase mRNA production in grapevine leaves treated with biotic and abiotic phytoalexin elicitors. *Am J Enol Viticult* 55:60-64.
- Boselli E, Boulton RB, Thorngate JH, Frega NG (2004) Chemical and sensory characterization of DOC red wines from Marzhe (Italy) related to vintage and grape cultivars. *J Agric Food Chem* 52:3843-3854.
- Boss PK, Davies C, Robinson SP (1996) Expression of anthocyanin biosynthesis pathway genes in red and white grapes. *Plant Mol Biol* 32:565-569.
- Bouhamidi R, Prevost V, Nouvelot A (1998) High protection by grape seed proanthocyanidins (GSPC) of polyunsaturated fatty acids against UV-C induced peroxidation. *Comptes Rendus de l Academie des Sciences. Serie III* 321:31-38.
- Bowers J, Boursiquot JM, This P, Chu K, Johansson H, Meredith C (1999) Historical genetics: the parentage of Chardonnay, Gamay, and other wine grapes of northeastern France. *Science* 285:1562-1565.
- Bravo MN, Silva S, Coelho AV, Boas LV, Bronze MR (2006) Analysis of phenolic compounds in Muscatel wines produced in Portugal. *Anal Chim Acta* 563:84-92.
- Brekša AP, Takeoka GR, Hidalgo MB, Vilches A, Vasse J, Ramming DW (2010) Phenolic Content of Raisin Grape Varieties and Genotypes. *Food Chem* 121:740-745.
- Brescia MA, Caldara V, De Giglio A, Benedetti D, Fanizzi FP, Sacco A (2002) Characterization of the geographical origin of Italian red wines based on traditional and nuclear magnetic resonance spectrometric determinations. *Anal Chim Acta* 458:177-186.
- Broeckling CD, Huhman DV, Farag MA, Smith JT, May GD, Mendes P, Dixon RA, Sumner LW (2005) Metabolic profiling of *Medicago truncatula* cell cultures reveals the effects of biotic and abiotic elicitors on metabolism. *J Exp Bot* 56:323-326.
- Brown SC, Kruppa G, Dasseux JL (2005) Metabolomics applications of FT-ICR mass spectrometry. *Mass Spectrom Rev* 24:223-231.
- Brun S, Cabanis JC, Mestres JP (1986) Analytical chemistry. *Experientia* 42:893-904.
- Buiarelli F, Cocciolo F, Jasionowska R, Merolle M, Terracciano A (2007) Analysis of some stilbenes in Italian wines by liquid chromatography/tandem mass spectrometry. *Rapid Commun Mass Sp* 21:2955-2964.
- Busam G, Junghanns KT, Kneusel RE, Kassemeyer HH, Matern U (1997) Characterization and expression of caffeoylcoenzyme A 3-O-methyltransferase proposed for the induced resistance response of *Vitis vinifera* L. *Plant Physiol* 115:1039-1048.
- Cabrita MJ, Freitas AMC, Laureano O, Stefano RD (2006) Glycosidic aroma compounds of some Portuguese grape cultivars. *J Sci Food Agric* 86:922-931.
- Cai Y, Jiang G, Liu J, Zhou Q (2003) Multi-walled carbon nanotubes packed cartridge for the solid-phase extraction of several phthalate esters from water samples and their determination by high performance liquid chromatography. *Anal Chim Acta* 494:149-156.
- Cambon B, Monteil V, Remize F, Camarasa C, Dequin S (2006) Effects of *GDP1* overexpression in *S. cerevisiae* commercial wine yeast strain lacking *ALD6* genes. *Appl Environ Microb* 72:4688-4694.
- Cardoso-Taketa AT, Pereda-Miranda R, Choi YH, Verpoorte R, Villarreal ML (2008) Metabolic profiling of the Mexican anxiolytic and sedative plant *Galphimia glauca* using nuclear magnetic resonance spectroscopy and multivariate data analysis. *Planta Med* 74:1295-1301.
- Carrari F, Urbanczyk-Wochniak E, Willmitzer L, Fernie AR (2003) Engineering central metabolism in crop species: learning the system. *Metab Eng* 5:191-200.
- Castellari M, Versari A, Spinabelli U, Galassi S, Amati A (2000) An improved HPLC method for the analysis of organic acids, carbohydrates and alcohols in grape musts and wines. *J Liq Chromatogr R T* 23:2047-2056.
- Castillo-Sánchez JJ, Mejuto JC, Garrido J, García-Falcón S (2006) Influence of wine-making protocol and fining agents on the evolution of anthocyanin content, colour and general organoleptic quality of Vinhão wines. *Food Chem* 97:130-136.
- Celimene CC, Smith DR, Young RA, Stanosz GR (2001) *In Vitro* inhibition of *Sphaeropsis sapinea* by natural stilbenes. *Phytochemistry* 56:161-165.
- Chamkha M, Cathala B, Cheynier V, Douillard R (2003) Phenolic compositions of champagnes from Chardonnay and Pinot Noir vintages. *J Agric Food Chem* 51:3179-3184.
- Chan EC, Yap SL, Lau AJ, Leow PC, Toh DF, Koh HL (2007) Ultra performance liquid chromatography / time of flight mass spectrometry based metabolomics of raw and steamed *Panax notoginseng*. *Rapid Commun Mass Sp* 21:519-528.

- Charlton AJ, Farrington WHH, Brereton P (2002) Application of ^1H NMR and multivariate statistics for screening complex mixtures: quality control and authenticity of instant coffee. *J Agric Food Chem* 50:3098-3103.
- Chen ECH (1978) The relative contribution of Ehrlich and biosynthetic pathways to the formation of fusel alcohols. *J Am Soc Brew Chem* 36:39-43.
- Cheynier VF, Trousdale EK, Singleton VL, Salgues MJ, Wylde R (1986) Characterization of 2-S-glutathionylcaftaric acid and its hydrolysis in relation to grape wines. *J Agric Food Chem* 34:217-221.
- Cho JY, Park J, Kim PS, Chae SH, Yoo ES, Baik KU, Lee J, Park MH (1999) Inhibitory effect of sesquiterpenelactones from *Saussurea lappa* on tumor necrosis factor- α production in murine macrophage-like cells. *Planta Med* 64:594-597.
- Cho JY, Park J, Kim PS, Yoo ES, Baik KU, Park MH (2001) Savinin, a lignan from *Pterocarpus santalinus* inhibits tumor necrosis factor- α production and T cell proliferation. *Biol Pharm Bull* 24:167-171.
- Cho SK, Yang S-O, Kim SH, Kim H, Ko JS, Riu KZ, Lee H-Y, Choi H-K (2009) Classification and prediction of free-radical scavenging activities of dangyuja (*Citrus grandis* Osbeck) fruit extracts using ^1H NMR spectroscopy and multivariate statistical analysis. *J Pharmaceut Biomed* 49:567-571.
- Choi HK, Choi YH, Verberne M, Lefeber AWM, Erkelens C, Verpoorte R (2004a) Metabolic fingerprinting of wild type and transgenic tobacco plants by ^1H NMR and multivariate analysis technique. *Phytochemistry* 65:857-864.
- Choi YH, Kim HK, Hazekamp A, Erkelens C, Lefeber AWM, Verpoorte R (2004b) Metabolomic Differentiation of *Cannabis sativa* Cultivars Using ^1H NMR Spectroscopy and Principal Component Analysis. *J Nat Prod* 67:953-957.
- Choi YH, Choi HK, Peltenburg-Looman AMG, Lefeber AWM, Verpoorte R (2004c) Quantitative analysis of ginkgolic acids from *Ginkgo* leaves and products using ^1H -NMR. *Phytochem Anal* 15:325-330.
- Choi YH, Sertic S, Kim HK, Wilson EG, Michopoulos F, Lefeber AWM, Erkelens C, Kricun SDP, Verpoorte R (2005) Classification of *Ilex* Species Based on Metabolomic Fingerprinting Using Nuclear Magnetic Resonance and Multivariate Data Analysis. *J Agric Food Chem* 53:1237-1245.
- Choi YH, Kim HK, Linthorst HJM, Hollander JG, Lefeber AWM, Erkelens C, Nuzillard J-M, Verpoorte R (2006) NMR metabolomics to revisit the Tobacco Mosaic Virus infection in *Nicotiana tabacum* leaves. *J Nat Prod* 69:742-8.
- Choy EHS, Panayi GS (2001) Cytokine Pathways and Joint Inflammation in Rheumatoid Arthritis. *N Engl J Med* 344:907-916.
- Christen D, Schönmann S, Jermini M, Strasser RJ, Défago G (2007) Characterization and early detection of grapevine (*Vitis vinifera*) stress responses to esca disease by *in situ* chlorophyll fluorescence and comparison with drought stress. *Environ Exp Bot* 60:504-514.
- Chuang C-C, Bumrungpert A, Kennedy A, Overman A, West T, Dawson B, McIntosh MK (2010a) Grape powder extracts attenuates tumor necrosis factor α -mediated inflammation and insulin resistance in primary cultures of human adipocytes. *J Nutr Biochem* 22:89-94.
- Chuang CC, Martinez K, Xie G, Kennedy A, Bumrungpert A, Overman A, Jia W, McIntosh MK (2010b) Quercetin is equally or more effective than resveratrol in attenuating tumor necrosis factor α -mediated inflammation and insulin resistance in primary human adipocytes. *Am J Clin Nutr* 92:1511-1521
- Chung KT, Lu Z, Chou MW (1998) Mechanism of inhibition of tannic acid and related compounds on the growth of intestinal bacteria. *Food Chem Toxicol* 36:1053-1060.
- Clayton TA, Lindon JC, Cloarec O, Antti H, Charuel C, Hanton G, Provost J-P, Le-Net J-L, Baker D, Walley RJ, Everett JR, Nicholson JK (2006) Pharmaco-metabonomic phenotyping and personalized drug treatment. *Nature* 440:1073-1077.
- Colova-Tsolova V (2000) A highly efficient *Agrobacterium* transformation system in grape embryogenic cell suspension enable co-transformation using simultaneously two *Agrobacteria* carrying different selectable markers. *Hortic Sci* 35:393-394.
- Colquhoun IJ (2007) Use of NMR for metabolic profiling in plant systems. *J Pestic Sci* 32:200-212.
- Conde C, Agasse A, Glissant D, Tavaras RM, Geros H, Derlot S (2006) Pathways of glucose regulation of monosaccharide transport in grape cells. *Plant Physiol* 141:1563-1577.
- Cook D, Fowler S, Fiehn O, Thomashow MF (2004) A prominent role for the CBF cold response pathway in configuring the low-temperature metabolome of *Arabidopsis*. *P Natl Acad Sci USA* 101:15243-15248.
- Coombe BG (1992) Research on development and ripening of the grape berry. *Am J Enol Viticult* 43:101-110.
- Coombe BG (1995) Growth stages of the grapevine: Adoption for a system for identifying grapevine growth stages. *Aust J Grape Wine R* 1:100-110.
- Cooper HJ, Marshall AG (2001) Electrospray Ionization Fourier Transform Mass Spectrometric Analysis of Wine. *J Agric Food Chem* 49:5710-5718.

References

- Cordova AC, Jackson LS, Berk-Schlessel DW, Sumpio BE (2005) The cardiovascular protective effect of red wine. *J Am Coll Surg* 200:428-439.
- Cordova AC, Sumpio BE (2009) Polyphenols are medicine: Is it time to prescribe red wine for our patients? *Int J Angiol* 18:111-117.
- Creasy LL, Coffee M (1988) Phytoalexin production potential of grape berries. *J Am Soc Hortic Sci* 113:230-234.
- Crippen DD, Jr. Morrison JC (1986) The effects of sun exposure on the phenolic content of Cabernet Sauvignon berries during development. *Am J Enol Viticult* 37:243-247.
- Crockford DJ, Holmes E, Lindon JC, Plumb RS, Zirah S, Bruce SJ, Rainville P, Stumpf CL, Nicholson JK (2006) Statistical heterospectroscopy, and approach to the integrated analysis of NMR and UPLC-MS data sets: Application in metabonomic toxicology studies. *Anal Chem* 78:363-371.
- Cuadros-Inostroza A, Giavalisco P, Hummel J, Eckardt A, Willmitzer L, Peña-Cortés H (2010) Discrimination of wine attributes by metabolome analysis. *Anal Chem* 82:3573-3580.
- Cuendet M, Potterat O, Salvi A, Testa B, Hostettmann K (2000) A stilbene and dihydrochalcones with radical scavenging activities from *Loiseleuria procumbens*. *Phytochemistry* 54:871-874.
- Daayf F, Ongena M, Boulanger R, El-Hadrami I, Belanger RR (2000) Induction of phenolic compounds in two cultivars of cucumber by treatment of healthy and powdery mildew infected plants with extracts of *Reynoutria sachalinensis*. *J Chem Ecol* 26:1579-1593.
- Dallüge J, Beens J, Brinkman UAT (2003) Comprehensive two-dimensional gas chromatography: a powerful and versatile analytical tool. *J Chromatogr A* 1000:69-108.
- David MG, Robert CS, Roger CP, Wayne FW, Richard MD (2001) Effects of powdery mildew on vine growth, yield, and quality of concord grapes. *Plant Dis* 85:137-140.
- Davies C, Robinson SP (2000) Differential screening indicates a dramatic change in mRNA profiles during grape berry ripening. Cloning and characterization of cDNAs encoding putative cell wall and stress response proteins. *Plant Physiol* 122:803-812.
- de Bolt S, Cook DR, Ford CM (2006) L-Tartaric acid synthesis from vitamin-C in higher plants. *P Natl Acad Sci USA* 103:5608-5613.
- De Pascual-Teresa S, Rivas-Gonzalo JC, Santos-Buelga C (2000) Prodelphinidins and related flavanols in wine. *Int J Food Sci Tech* 35:33-40.
- De Vos RCH, Moco S, Lommen A, Keurentjes JJB, Bino RJ, Hall RD (2007) Untargeted large-scale plant metabolomics using liquid chromatography coupled to mass spectrometry. *Nat Protoc* 2:778-791.
- Defernez M, Gunning YM, Parr AJ, Shepherd LVT, Davies HV, Colquhoun IJ (2004) NMR and HPLC-UV profiling of potatoes with genetic modifications to metabolic pathways. *J Agric Food Chem* 52:6075-6085.
- DellaPenna D (2001) Plant metabolic engineering. *Plant Physiol* 125:160-163.
- Derckel JP, Baillieux F, Manteau S, Audran JC, Haye B, Lambert B, Legendre L (1999) Differential induction of grapevine defenses by two strains of *Botrytis cinerea*. *Phytopathology* 89:197-203.
- Dercks W, Creasy LL (1989) The significance of stilbene phytoalexins in the *Plasmopara Viticola* grapevine interaction. *Physiol Mol Plant Pathol* 34:189-202.
- Desbrosses GG, Kopka J, Udvardi MK (2005) *Lotus japonicus* Metabolic Profiling. Development of Gas Chromatography-Mass Spectrometry Resources for the Study of Plant-Microbe Interactions. *Plant Physiol* 137:1302-1318.
- Dettmer K, Aronov PA, Hammock BD (2007) Mass spectrometry-based metabolomics. *Mass Spectrom Rev* 26:51-78.
- D'Imperio M, Mannina L, Capitani D, Bidet O, Rossi E, Bucarelli FM, Quaglia GB, Segre A (2007) NMR and statistical study of olive oils from Lazio: a geographical, ecological and agronomic characterization. *Food Chem* 105:1256-1267.
- Dixon RA (2001) Natural products and plant disease resistance. *Nature* 411:843-847.
- Dixon RA, Gang DR, Charlton AJ, Fiehn O, Kuiper HA, Reynolds TL, Tjeerdema RS, Jeffery EH, German JB, Ridley WP, Seiber JN (2006) Applications of Metabolomics in Agriculture. *J Agric Food Chem* 54:8984-8994.
- Downey M, Harvey J, Robinson S (2003) Synthesis of flavonols and expression of flavonol synthase genes in the developing grape berries of Shiraz and Chardonnay (*Vitis vinifera* L.). *Austr J Grape Wine Res* 9:110-121.
- Downie A, Miyazaki S, Bonnert H, John P, Coleman J, Parry M, Haslam R (2004) Expression profiling of the response of *Arabidopsis thaliana* to methanol stimulation. *Phytochemistry* 65:2305-2016.
- Duarte I, Barros A, Belton PS, Righelato R, Spraul M, Humpfer E, Gil AM (2002) High-Resolution Nuclear Magnetic Resonance Spectroscopy and Multivariate Analysis for the Characterization of Beer. *J Agric Food Chem* 50:2475-2481.

- Dunn WB, Ellis DI (2005) Metabolomics: current analytical platforms and methodologies. *Trends Anal Chem* 24:285–294.
- Duxbury M, Hotter G, Reglinski T, Sharpe N (2004) Effect of Chitosan and 5-Chlorosalicylic Acid on total phenolic content of Grapes and Wine. *Am J Enol Viticult* 55:191–194.
- Eibach R, Töpfer R (2003) Success in resistance breeding: ‘Regent’ and its steps into the market. *Acta Hort* 603:687–691.
- Elmer PAG, Reglinski T (2006) Biosuppression of *Botrytis cinerea* in grapes. *Plant Pathol* 55:155–177.
- Eriksson L, Johansson E, Kettaneh-Wold N, Trygg J, Wikstrom C, Wold S (2006) Multi- and megavariate data analysis, Umetrics Academy, Umeå.
- Escudero A, Hernandez-Orte P, Cacho J, Ferreira V (2000) Clues about the role of methional as character impact odorant of some oxidized wines. *J Agric Food Chem* 48:4268–4272.
- Falcão LD, de Revel G, Rosier JP, Bordignon-Luiz MT (2008) Aroma impact components of Brazilian Cabernet Sauvignon using detection frequency analysis (GC-olfactometry). *Food Chem* 107:497–505.
- Farmer EE, Ryan CA (1990) Interplant communication: Airborne methyl jasmonate induces synthesis of proteinase inhibitors in plant leaves. *P Natl Acad Sci USA* 87:7713–7716.
- Fernie AR, Willmitzer L, Trethewey RN (2002) Sucrose to starch: a transition in molecular plant physiology. *Trends Plant Sci* 7:35–41.
- Ferreira RB, Piçarra-Pereira MA, Monteiro S, Loureiro VB, Teixeira AR (2001) The wine proteins. *Trends Food Sci Tech* 12:230–239.
- Fiehn O, Kopka J, Dormann P, Altmann T, Trethewey RN, Willmitzer L (2000) Metabolite profiling for plant functional genomics. *Nat Biotechnol* 18:1157–1161.
- Fiehn O (2002) Metabolomics – the link between genotypes and phenotypes. *Plant Mol Biol* 48:155–71.
- Figueiredo A, Fortes AM, Ferreira S, Sebastiana M, Choi YH, Sousa L, Acioli-Santos B, Pessoa F, Verpoorte R, Pais MS (2008) Transcriptional and metabolic profiling of grape (*Vitis vinifera* L.) leaves unravel possible innate resistance against pathogenic fungi. *J Exp Bot* 59:3371–3381.
- Fillion L, Ageorges A, Picaud S, Coutos-Thevenot PL, Romieu C, Delrot S (1999) Cloning and expression of a hexose transporter gene expressed during the ripening of grape berry. *Plant Physiol* 120:1083–1094.
- Flechtner-Mors M, Biesalski HK, Jenkinson CP, Adler G, Ditschuneit HH (2004) Effects of moderate consumption of white wine on weight loss in overweight and obese subjects. *Int J Obes Relat Metab Disord* 28:1420–1426.
- Folts JD (2002) Potential health benefits from the flavonoids in grape products on vascular disease. *Adv Exp Med Biol* 505:95–111.
- Fournand D, Vicens A, sidhoum L, Souquet JM, Moutounet M, Cheynier V (2006) Accumulation and extractability of grape skin tannins and anthocyanins at different advanced physiological stages. *J Agric Food Chem* 54:7331–7338.
- Fracaroli M, Nicolletti S, Maltese F, Choi YH, Guzzo F, Levi M, Verpoorte R (2008) Pre-Analytical method for metabolic profiling of plant cell suspension cultures of *Passiflora grackei*. *Biotechnol Lett* 30:2031–2036.
- Fraille P, Garrido J, Ancin C (2000) Influence of a *Saccharomyces cerevisiae* selected strain in the volatile composition of rose wines. Evolution during fermentation. *J Agric Food Chem* 48:1789–1798.
- Frankel EN, Kanner J, German JB, Parks E, Kinsella JE (1993) Inhibition of oxidation of human low-density lipoprotein by phenolic substances in red wine. *Lancet* 341:454–457.
- Frankel WN, Waterhouse AL, Teissedre PL (1995) Principal phenolic phytochemicals in selected California wines and their antioxidant activity in inhibiting oxidation of human low-density lipoproteins. *J Agric Food Chem* 43:890–894.
- Fuhrman B, Volkova N, Coleman R, Aviram M (2005) Grape powder polyphenols attenuate atherosclerosis development in eapolipoprotein E deficient (E0) mice and reduce macrophage atherogenicity. *J Nutr* 135:722–728.
- Fulcrand H, Remy S, Souquet JM, Cheynier V, Moutounet M (1999) Study of wine tannins oligomers by on-line chromatography electrospray ionization mass spectrometry. *J Agric Food Chem* 47:1023–1028.
- Gabler FM, Smilanick JL, Mansour M, Ramming DW, Mackey BE (2003) Correlations of morphological, anatomical, and chemical features of grape berries with resistance to *Botrytis cinerea*. *Phytopathology* 93:1263–1273.
- Galili G, Hofgen R (2002) Metabolic engineering of amino acids and storage proteins in plants. *Metab Eng* 4:3–11.
- Gambuti A, Strollo D, Ugliano M, Lecce L, Moio L (2004) *trans*-Resveratrol, quercetin, (+)-catechin, and (-)-epicatechin content in south Italian monovarietal wines: Relationship with maceration time and marc pressing during winemaking. *J Agric Food Chem* 52:5747–5751.

References

- Gardini F, Zaccarelli A, Belletti N, Faustini F, Cavazza A, Maruscelli M, Mastrocola D, Suzzi G (2005) Factors influencing biogenic amine production by a strain of *Oenococcus oeni* in a model system. *Food Control* 16:609-618.
- Gergaud O, Ginsburgh V (2008) Natural endowments, production technologies and the quality of wines in Bordeaux. Does terrior matter? *Econ J* 118:F142-F157.
- German JB, Walzem RL (2000) The health benefits of wine. *Annu Rev Nutr* 20:561-593.
- Giannakis C, Bucheli CS, Skene KGM, Robinson SP, Scott NS (1998) Chitinase and β -1,3-glucanase in grapevine leaves: a possible defence against powdery mildew infection. *Aust J Grape Wine R* 4:14-22.
- Gilard V, Balayssac S, Malet-Martino M, Martino R (2010) Quality Control of Herbal Medicines Assessed by NMR. *Curr Pharm Anal* 6:234-245.
- Giovannoni JJ (2004) Genetic regulation of fruit development and ripening. *Plant Cell* 16 Suppl:S170-180.
- Giraudel JL, Setkova L, Pawliszyn J, Montury M (2007) Rapid headspace solid-phase microextraction-gas chromatographic-time-of-flight mass spectrometric method for qualitative profiling of ice wine volatile fraction. III. Relative characterization of Canadian and Czech ice wines using self-organizing maps. *J Chromatogr A* 1147:241-253.
- Given NK, Venis MA, Gierson D (1988) Hormonal regulation of ripening in the strawberry, a non-climacteric fruit. *Planta* 174:402-406.
- Gobey J, Cole M, Janiszewski J, Covey T, Chau T, Kovarik P, Corr J (2005) Characterization and performance of MALDI on a triple quadrupole mass spectrometer for analysis and quantification of small molecules. *Anal Chem* 77:5463-5654.
- Goetz G, Fkyerat A, Metais N, Kunz M, Tabacchi R, Pezet R, Pont V (1999) Resistance factors to grey mould in grape berries: identification of some phenolics inhibitors of *Botrytis cinerea* stilbene oxidase. *Phytochemistry* 52:759-767.
- González-Manzano S, Santos-Buelga C, Pérez-Alonso JJ, Rivas-Gonzalo JC, Escribano-Bailón MT (2006) Characterization of the mean degree of polymerization of proanthocyanidins in red wines using liquid chromatography-mass spectrometry (LC-MS). *J Agric Food Chem* 54:4326-4332.
- González-Neves G, Gil G, Ferrer M (2002) Effect of different vineyard treatments on the phenolic contents in Tannat (*Vitis vinifera* L.) grapes and their respective wines. *Food Sci Technol Int* 8:315-321.
- Goodacre R, Shann B, Gilbert RJ, Timmins EM, McGovern AC, Alsberg BK, Kell DB, Logan NA (2000) Detection of the Dipicolinic Acid Biomarker in *Bacillus* Spores Using Curie-Point Pyrolysis Mass Spectrometry and Fourier Transform Infrared Spectroscopy. *Anal Chem* 72:119-127.
- Goodacre R, Vaidyanathan S, Dunn WB, Harrigan GG, Kell DB (2004) Metabolomics by numbers: acquiring and understanding global metabolite data. *Trends Biotechnol* 22:245-252.
- Gougeon RD, Lucio M, Frommberger M, Peyron D, Charragne D, Alexandre H, Feuillat F, Voilley A, Cayot P, Gebefügi I, Hertkorn N, Schmitt-Kopplin P (2009) The chemodiversity of wines can reveal a metabo-geography expression of cooperage oak wood. *P Natl Acad Sci USA* 106:9174-9179.
- Gryglewski RJ, Korbut R, Robak J, Swies J (1987) On the mechanism of antithrombotic action of flavonoids. *Biochem Pharmacol* 36:317-322.
- Guasch-Jane MR, Ibern-Gomez M, Andres-Lacueva C, Juregui O, Lamuela-Ravents RM (2004) Liquid chromatography with mass spectrometry in Tandem mode applied for the identification of wine markers in residues from ancient Egyptian vessels. *Anal Chem* 76:1672-1677.
- Guebaila HA, Chira K, Richard T, Mabrouk T, Furiga A, Vitrac X, Monti JP, Delaunay JC, Merillon JM (2006) Hopeaphenol: The first resveratrol tetramer in wines from North Africa. *J Agric Food Chem* 54:9559-9564.
- Hakansson E, Pardon K, Hayasaka Y, de Sa M, Herderich M (2003) Structures and colour properties of new red wine pigments. *Tetrahedron Lett* 44:4887-4891.
- Hall RD, Vos CHR, Verhoeven HA, Bino RJ (2005) Metabolomics for the assessment of functional diversity and quality traits in plants. In: Vaidyanathan S, Harrigan GG, Goodacre R (eds) *Metabolome analyses: strategies for systems biology*, Springer, New York.
- Halpern GM (2008) A celebration of wine: wine is medicine. *Inflammopharmacology* 16:240-244.
- Hammerschmidt R, Smith-Becker JA (1999) The role of salicylic acid in disease resistance. In: Agarwal AA, Tuzum S, Bent E. (eds.) *Induced Plant Defenses against Pathogens and Herbivores*. St Paul, MN: APS Press, pp. 37-54.
- Hamzehzarghani H, Kushalappa AC, Dion Y, Rioux S, Comeau A, Yaylayan V, Marshall WD, Mather DE (2005) Metabolic profiling and factor analysis to discriminate quantitative resistance in wheat cultivars against fusarium head blight. *Physiol Mol Plant P* 66:119-133.
- Hansen AS, Marckmann P, Dragsted LO, Finne-Nielsen IL, Nielsen SE, Gronbaek M (2005) Effect of red wine and red grape extract on blood lipids, haemostatic factors, and other risk factors for cardiovascular disease. *Eur J Clin Nutr* 59:449-455.

- Hansen C (1995) Grape Seed Extract: Procyanidolic Oligmers (PCO). Healing Wisdom Publications, New York.
- Harbertson JF, Kennedy JA, Adams DO (2002) Tannin in skins and seeds of Cabernet Sauvignon, Syrah, and Pinot noir berries during ripening. *Am J Enol Viticult* 53:54-59.
- Harborne JB (1999) The comparative biochemistry of phytoalexin induction in plants. *Biochem Syst Ecol* 27:335-367.
- Harborne JB (2001) Twenty-five years of chemical ecology. *Nat Prod Rep* 18:361-379.
- Hayasaki Y, Adams KS, Pocock KF, Baldock GA, Waters EJ, Hoj PB (2001) Use of electrospray mass spectrometry for mass determination of grape (*Vitis vinifera*) juice pathogenesis-related proteins: A potential tool for varietal differentiation. *J Agric Food Chem* 49:1830-1839.
- Hendrawati O, Yao Q, Kim HK, Linthorst HJM, Erkelens C, Lefeber AWM, Choi YH, Verpoorte R (2006) Metabolic differentiation of *Arabidopsis* treated with methyl jasmonate using nuclear magnetic resonance spectroscopy. *Plant Sci* 170:1118-1124.
- Herath HMT, Takano-Ishikawa Y, Yamaki K (2003) Inhibitory effect of some flavonoids on tumor necrosis factor- α production in lipopolysaccharide-stimulated mouse macrophage cell line J774.1. *J Med Food* 365-370.
- Herbert P, Cabrita MJ, Ratola N, Laureano O, Alves A (2005) Free amino acids and biogenic amines in wines and musts from the Alentejo region. Evolution of amines during alcoholic fermentation and relationship with variety, sub-region, and vintage. *J Food Eng* 66:315-322.
- Hernandez-Orte P, Cacho J, Ferreira V (2002) Relationship between varietal amino acid profile of grapes and wine aromatic composition. Experiments with model solutions and chemometric study. *J Agric Food Chem* 50:2891-2899.
- Hernandez-Orte P, Ibrax MJ, Cacho J, Ferreira V (2003) Amino acid determination in grape juices and wines by HPLC using a modification of the 6-animoquinolyl-n-hydrosysuccinimidyl carbamate (AQC) method. *Chromatographia* 58:29-35.
- Hernandez-Orte P, Belly M, Cacho J, Ferreira V (2006) Impact of ammonium additions on volatile acidity, ethanol, and aromatic compound production by different *Saccharomyces cerevisiae* strains during fermentation in controlled synthetic media. *Aust J Grape Wine R* 12:150-160.
- Hirai MY, Yano M, Goodenowe DB, Kanaya S, Kimura T, Awazuwara M, Arita M, Fujiwara T, Kazuki Saito (2004) Integration of transcriptomics and metabolomics for understanding of global responses to nutritional stresses in *Arabidopsis thaliana*. *P Natl Acad Sci* 101:10205-10210.
- Hirai MY, Klein M, Fujikawa Y, Yano M, Goodenowe DB, Yamazaki Y, Kanaya S, Nakamura Y, Kitayama M, Suzuki H, Sakurai N, Shibata D, Tokuhisa J, Reichelt M, Gershenzon J, Papenbrock J, Saito K (2005) Elucidation of Gene-to-gene networks in *Arabidopsis* by integration of metabolomics and transcriptomics. *J Biol Chem* 280:25590-15595.
- Hrazdina G, Parsons GF, Mattick LR (1984) Physiological and biochemical events during development and maturation of grape berries. *Am J Enol Viticult* 35:220-227.
- Hufnagel JC, Hofmann T (2008) Quantitative reconstruction of the nonvolatile sensometabolome of a red wine. *J Agric Food Chem* 56:9190-9199.
- Hughes EH, Shanks JV (2002) Metabolic engineering of plants for alkaloid production. *Metab Eng* 4:41-48.
- Hyberts SG, Heffron GJ, Tarragona NG, Solanky K, Edmonds KA, Luithardt H, Fejzo J, Chorev M, Aktas H, Colson K, Falchuk KH, Halperin JA, Wagner G (2007) Ultrahigh-resolution ^1H - ^{13}C HSQC spectra of metabolite mixtures using nonlinear sampling and forward maximum entropy reconstruction. *J Agric Food Chem* 129:5108-5116.
- Iglesias M, Besalú E, Anticó E (2007) Internal standardization-Atomic spectrometry and geographical pattern recognition techniques for the analysis and classification of catalonian red wines. *J Agric Food Chem* 55:219-225.
- 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.
- Iriti M, Faoro F (2006) Grape phytochemicals: A bouquet of old and new nutraceuticals for human health. *Med Hypotheses* 67:833-838.
- Jackson RS (2000) Wine Science: Principles, Practice, Perception. Academic Press, California.
- Jacob JK, Hakimuddin F, Paliyath G, Fisher H (2008) Antioxidant and antiproliferative activity of polyphenols in novel high-polyphenol grape lines. *Food Res Int* 41:419-428.
- Jacobs AK, Dry IB, Robinson SP (1999) Powdery mildew infection and ethephon treatment induce different pathogenesis-related cDNAs in grapevine. *Plant Pathol* 48:325-336.
- Jaitz L, Siegl K, Eder R, Rak G, Abranko L, Koellensperger G, Hann S (2010) LC-MS/MS analysis of phenols for classification of red wine according to geographic origin, grape variety and vintage. *Food Chem* 122:366-372.

References

- Jander G, Norris SR, Joshi V, Fraga M, Rugg AYS, Li L, Last RL (2004) Application of a high-throughput HPLC-MS/MS assay to *Arabidopsis* mutant screening; evidence that threonine aldolase plays a role in seed nutritional quality. *Plant J* 39:465–475.
- Jang M, Cai L, Udeani GO, Slowing KV, Thomas CF, Beecher CWW, Fong HH S, Farnsworth NR, Hinghorn AD, Mehta RG, Moon RC, Pezzuto JM (1997) Cancer chemopreventive activity of resveratrol, a natural product derived from grapes. *Science* 275:218–220.
- Jansen JJ, Smit S, Hoefsloot HCJ, Smilde AK (2010) The photographer and the greenhouse: How to analyse plant metabolomics data. *Phytochem Anal* 21:48–60.
- Jean-Denis JB, Pezet R, Tabacchi R (2006) Rapid analysis of stilbenes and derivatives from downy mildew-infected grapevine leaves by liquid chromatography-atmospheric pressure photoionisation mass spectrometry. *J Chromatogr A* 1112:263–268.
- Jeandet P, Bessis R, Gautheron B (1991) The production of resveratrol (3,5,4-trihydroxystilbene) by grape berries in different developmental stages. *Am J Enol Viticult* 42:41–46.
- Jeandet P, Bessis R, Sbaghi M, Meunier P (1995) Production of the phytoalexin resveratrol by grapes as a response to *Botrytis* attack under natural conditions. *J Phytopathol* 143:135–139.
- Jeandet P, Adrian M, Breuil AC, Sbaghi M, Debord S, Bessis R, Weston LA, Harmon R (2000) Chemical induction of phytoalexin synthesis in grapevines: application to the control of grey mould in the vineyard. *Acta Hort* 528:591–596.
- Jeandet P, Douillet-Breuil AC, Bessis R, Debord S, Sbaghi M, Adrian M (2002) Phytoalexins from the Vitaceae: Biosynthesis, phytoalexin gene expression in transgenic plants, antifungal activity, and metabolism. *J Agric Food Chem* 50:2731–2741.
- Kaddurah-Daouk R, Beecher C, Kristal BS, Matson WR, Bogdanov M, Asa DJ (2004) Bioanalytical advances for metabolomics and metabolic profiling. *Pharmagenomics* 4:46–52.
- Kanner J, Frankel E, Granit R, German B, Kinsella JE (1994) Natural antioxidants in grapes and wines. *J Agric Food Chem* 42:64–69.
- Kant MR, Ament K, Sabelis MW, Haring MA, Schuurink RC (2004) Differential timing of spider mite-induced direct and indirect defenses in tomato plants. *Plant Physiol* 135:483–495.
- Kaur G, Roberti M, Raul F, Pendurthi UR (2007) Suppression of human monocyte tissue factor induction by red wine phenolics and synthetic derivatives of resveratrol. *Thromb Res* 119:247–256.
- Keller M, Viret O, Cole M (2003) *Botrytis cinerea* infection in grape flowers: defense reaction, latency and disease expression. *Phytopathology* 93:316–322.
- Kennedy JA (2008) Grape and wine phenolics: Observations and recent findings. *Cienc Investig Agrar* 35:107–120.
- Khanna S, Roy S, Bagchi D, Bagchi M, Sen CK (2001) Upregulation of oxidant-induced VEGF expression in cultured keratinocytes by a grape seed proanthocyanidin extract. *Free Rad Bio Med* 31:38–42.
- Kikkert JR, Thomas MR, Reisch BI (2001) Grapevine genetic engineering. In: Roubelakis-Angelakis KA (ed) *Molecular Biology and Biotechnology of the Grapevine*. Kluwer Academic Publishers, Dordrecht, pp. 393–463.
- Kikuchi J, Shinozaki K, Hirayama T (2004) Stable isotope labeling of *Arabidopsis thaliana* for an NMR-based metabolomics approach. *Plant Cell Physiol* 45:1099–1104.
- Kim HK, Choi YH, Erkelens C, Lefeber AWM, Verpoorte R (2005) Metabolic Fingerprinting of *Ephedra* Species Using ¹H-NMR Spectroscopy and Principal Component Analysis. *Chem Pharm Bull* 53:105–109.
- Kim HK, Choi YH, Verpoorte R (2010a) NMR-based metabolomic analysis of plants. *Nat Protoc* 5:536–549.
- Kim HK, Saifullah, Khan S, Wilson EG, Kricun SDP, Meissner A, Goraler S, Deelder AM, Choi YH, Verpoorte R (2010b) Metabolic classification of South American *Ilex* species by NMR-based metabolomics. *Phytochemistry* 71:773–784.
- Kim HK, Verpoorte R (2010c) Sample preparation for plant metabolomics. *Phytochem Anal* 21:4–13.
- Kirwan GM, Clark S, Barnett NW, Niere JO, Adams MJ (2008) Generalised 2D-correlation NMR analysis of a wine fermentation. *Anal Chim Acta* 629:128–135.
- Klampfl CW, Buchberger W, Haddad PR (2000) Determination of organic acids in food samples by capillary zone electrophoresis. *J Chromatogr A* 881:357–364.
- Klampfl CW (2004) Review coupling of capillary electrochromatography to mass spectrometry. *J Chromatogr A* 1044:131–144.
- Kliewer WM (1966) Sugars and organic acids of *Vitis vinifera*. *Plant Physiol* 41:923–931.
- Kobayashi S, Ishimaru M, Ding CK, Yakushiji H, Goto N (2001) Comparison of UDP-glucose: Flavanoid 3-O-glucosyltransferase (UFGT) gene sequences between white grapes (*Vitis vinifera*) and their sports with red skin. *Plant Sci* 160:543–550.
- Kobayashi S, Ishimaru M, Hiraoka K, Honda C (2002) Myb related genes of the Kyoho grape (*Vitis labruscana*) regulate anthocyanin biosynthesis. *Planta* 215:924–933.

- Kopka J, Fernie A, Weckwerth W, Gibon Y, Stitt M (2004) Metabolite profiling in plant biology: platforms and destinations. *Genome Biol* 5:109.1-109.9.
- Kortekamp A, Welter L, Vogt S, Knoll A, Schwander F, Töpfer R, Zyprian E (2008) Identification, isolation, and characterization of a CC-NBS-LRR candidate disease resistance gene family in grapevine. *Mol Breed* 22:421-432.
- Kosir IJ, Kidric J (2001) Identification of amino acids in wines by one- and two-dimensional nuclear magnetic resonance spectroscopy. *J Agric Food Chem* 49:50-56.
- Kosir IJ, Kidric J (2002) Use of modern nuclear magnetic resonance spectroscopy in wine analysis: determination of minor compounds. *Anal Chim Acta* 458:77-84.
- Kosir IJ, Lapornik B, Andersek S, Wondra AG, Vrhovsek U, Kidric J (2004) Identification of anthocyanins in wines by liquid chromatography, liquid chromatography-mass spectrometry and nuclear magnetic resonance. *Anal Chim Acta* 513:277-282.
- Kourtils LK, Arvanitoyannis IS (2001) Implementation of hazard analysis critical control point (HACCP) system to the alcoholic beverages industry. *Food Rev Int* 17:1-44.
- Kraeva E, Tesniere C, Terrier N, Romieu C, Sauvage FX, Bierre J, Deloire A (1998) Transcription of a β -1,3-glucanase gene in grape berries in a late developmental period, or earlier after wounding treatments. *Vitis* 37:107-111.
- Kruger NJ, Troncoso-Ponce AT, Ratcliff RG (2008) ^1H NMR metabolite fingerprinting and metabolomic analysis of perchloric acid extracts from plant tissues. *Nat Protoc* 3:1001-1012.
- Kuc J (1995) Phytoalexins, stress metabolism, and disease resistance in plants. *Annu Rev of Phytopathol* 33:275-297.
- Landete JM, Polo L, Ferrer S, Pardo I (2005) Biogenic amines in wine from three spanish regions. *J Agric Food Chem* 53:1119-1124.
- Langcake P, Pryce RJ (1976) The production of resveratrol by *Vitis vinifera* and other members of the Vitaceae as a response to infection or injury. *Physiol Plant Pathol* 9:77-86.
- Langcake P, Pryce RJ (1977) The production of resveratrol and the viniferins by grapevines in response to ultraviolet irradiation. *Phytochemistry* 16:1193-1196.
- Langcake P (1981) Disease resistance of *Vitis* spp. and the production of the stress metabolites resveratrol, ϵ -viniferin, α -viniferin and pterostilbene. *Physiol Plant Pathol* 18:213-226.
- Large PJ (1986) Degradation of organic nitrogen compounds by yeasts. *Yeast* 2:1-34.
- Larsen FH, van den Berg F, Engelsen SB (2006) An exploratory chemometric study of ^1H NMR spectra of table wines. *J Chemometr* 20:198-208.
- Le Gall G, Puaud M, Colquhoun IJ (2001) Discrimination between orange juice and pulp wash by ^1H Nuclear magnetic resonance spectroscopy: Identification of marker compounds. *J Agric Food Chem* 49:580-588.
- Lee J-E, Hwang G-S, Berg FVD, Lee C-H, Hong Y-S (2009) Evidence of vintage effects on grape wines using ^1H NMR-based metabolomic study. *Anal Chim Acta* 648:71-76.
- Lessard PA, Kulaveerasingam H, York GM, Strong A, Sinskey AJ (2002) Manipulating gene expression for the metabolic engineering of plants. *Metab Eng* 4:67-79.
- Lewinsohn E, Schalechet F, Wilkinson J, Matsui K, Tadmor Y, Nam K, Amar O, Lastochkin E, Larkov O, Ravid U, Hiatt W, Gepstein S, Pichersky E (2001) Enhanced levels of aroma and flavor compound S-Linalool by metabolic engineering of terpenoid pathway in Tomato fruits. *Plant Physiol* 127:1256-1265.
- Lewis IA, Schommer SC, Hodis B, Robb KA, Tonelli M, Westler WM, Sussman MR, Markley JL (2007) Method for determining molar concentrations of metabolites in complex solutions from two-dimensional ^1H - ^{13}C NMR spectra. *Anal Chem* 79:9385-9390.
- Li X, Weng JK, Chapple C, (2008) Improvement of biomass through lignin modification. *Plant J* 54:569-581.
- Liang YS, Kim HK, Lefeber AWM, Erkelens C, Choi YH, Verpoorte R (2006) Identification of phenylpropanoids in methyl jasmonate treated *Brassica rapa* leaves using two-dimensional nuclear magnetic resonance spectroscopy. *J Chromatogr A* 1112:148-155.
- Lindon JC, Holmes E, Bollard ME, Stanley EG, Nicholson JK (2004) Metabonomics technologies and their applications in physiological monitoring, drug safety assessment and disease diagnosis. *Biomarkers* 9:1-31.
- Lisec J, Schauer N, Kopka J, Willmitzer L, Fernie A (2006) Gas chromatography mass spectrometry-based metabolite profiling in plants. *Nat Protoc* 1:387-396.
- Liu YM, Cheng JK (2002) Highly sensitive chemiluminescence detection of copper(II) in capillary electrophoresis with field-amplified sample injection. *Electrophoresis* 23:556-558.
- Liviero L, Puglisi PP (1994) Antimutagenic activity of procyanidins from *Vitis vinifera*. *Fitoterapia* 63:203-209.
- Lodhi MA, Reisch BI (1995) *In situ* hybridization in *Vitis vinifera* L. *Theor Appl Genet* 90:11-16.

References

- Loewus FA (1999) Biosynthesis and metabolism of ascorbic acid in plants and of analogs of ascorbic acid in fungi. *Phytochemistry* 52:193-210.
- Lokvam J, Brenes-Arguedas T, Lee JS, Coley PD, Kursar TA (2006) Allelochemic function for a primary metabolite: the case of l-tyrosine hyper-production in *Inga umbellifera* (Fabaceae). *Am J Bot* 93:1109-1115.
- Looser R, Krotzky A, Trethewey RN (2005) Metabolite profiling with GC-MS and LC-MS. In: Vaidyanathan S, Harrigan G, Goodacre R (eds) *Metabolome analyses strategies for systems biology*. Springer, New York.
- López-Gresa MP, Maltese F, Bellés JM, Conejero V, Kim HK, Choi YH, Verpoorte R (2010) Metabolic response of tomato leaves upon different plant-pathogen interactions. *Phytochem Anal* 21:89-94.
- López-Rituerto E, Cabredo S, Lopez M, Avenzoa A, Busto JH, Peregrina JM (2009) A thorough study on the use of quantitative ¹H NMR in Roja red wine fermentation processes. *J Agric Food Chem* 57:2112-2118.
- Lu YR, Foo LY (1999) The polyphenol constituents of grape pomace. *Food Chem* 65:1-8.
- Ma C, Wang H, Lu X, Xu G, Liu B (2008) Metabolic fingerprinting investigation of *Artemisia annua* L. in different stages of development by gas chromatography and gas chromatography mass spectrometry. *J Chromatogr A* 1186:412-419.
- Madden LV, Ellis MA, Lalancette N, Hughes G, Wilson LL (2000) Evaluation of a disease warning system for downy mildew of grapes. *Plant Dis* 84:549-554
- Malherbe S, Watts V, Nieuwoudt HN, Bauer FF, du Toit M (2009) Analysis of volatile profiles of fermenting grape must by headspace solid-phase dynamic extraction coupled with gas chromatography-mass spectrometry (HS-SPDE GC-MS): Novel application to investigate problem fermentations. *J Agric Food Chem* 57:5161-5166.
- Maltese F, van der Kooy F, Verpoorte R (2009) Solvent derived artifacts in natural products chemistry. *Nat Prod Commun* 4: 447-454.
- Mane C, Souquet JM, Olle D, Verries C, Veran F, Mazerolles G, Cheynier V, Fulcrand H (2007) Optimization of simultaneous flavanol, phenolic acid, and anthocyanin extraction from grapes using an experimental design: application to the characterization of Champagne grape varieties. *J Agric Food Chem* 55:7224-7233.
- Mangiapani H, Thomson J, Salter A, Brown S, Bell GD, White DA (1992) The inhibition of the oxidation of low density lipoprotein by (1)-catechin, a naturally occurring flavonoid. *Biochem Pharmacol* 43:445-450.
- Manna SK, Mukhopadhyay A, Aggarwal BB (2000) Resveratrol suppresses TNF-induced activation of nuclear transcription factors NF- κ B, activator protein-1 and apoptosis: potential role of reactive oxygen intermediates and lipids peroxidation. *J Immunol* 164: 6509-6519.
- Manthey JA, Buslig BS, Baker ME (2002) Flavonoids in cell function. *Adv Exp Med Biol* 505:1-7.
- Marambaud P, Zhao H, Davies P (2005) Resveratrol promotes clearance of Alzheimer's disease beta-amyloid peptides. *J Biol Chem* 280:37377-37382.
- Marcobal A, Martin-Alvarez PJ, Polo MC, Munoz R, Moreno-Arribas MV, (2006) Formation of biogenic amines throughout the industrial manufacture of red wine. *J Food Prot* 69:391-396.
- Mardones C, Hitschfeld A, Contreras A, Lepe K, Guitierrez L, von Baer D (2005) Comparison of shikimic acid determination by capillary zone electrophoresis with direct and indirect detection with liquid chromatography for varietal differentiation of red wines. *J Chromatogr A* 1085:285-292.
- Martelli GP, Savino V (1990) Fanleaf degeneration. In: Pearson R, Geheen AC (eds) *Compendium of Grape Diseases*. APS Press, St. Paul, pp. 48-49.
- Martelli GP (1993) Handbook for detection and diagnosis: grapevine degeneration Fanleaf. In: Martelli GP (ed) *Graft transmissible Diseases of Grapevines*. FAO. Rome, pp. 9-18.
- Matejček D, Mikes O, Klejdus B, Sterbová D, Kubán V (2005) Changes in contents of phenolic compounds during maturing of barrique red wines. *Food Chem* 90:791-800.
- Mateus N, Oliveira J, Santos-Buelga C, Silva AMS, de Freitas VAP (2004) NMR structural characterization of a new vinylpyranoanthocyanin-catechin pigment (a portisin). *Tetrahedron Lett* 45:3455-3457.
- Mato I, Suarez-Luque S, Huidobro JF (2005) A review of analytical methods to determine organic acids in grape juices and wines. *Food Res Int* 38:1175-1188.
- Mato I, Huidobro JF, Simal-Lozano J, Sancho MT (2006) Simultaneous determination in beverages by capillary zone electrophoresis. *Anal Chim Acta* 565:190-197.
- Mato I, Suarez-Luque S, Huidobro JF (2007) Simple determination of main organic acids in grape juice and wine by using capillary zone electrophoresis with direct UV detection. *Food Chem* 102:104-112.
- Matsumoto S, Shiraki K, Tsuji N, Hirata K, Miyamoto K, Takagi M (2004) Functional analysis of phytochelatin synthase from *Arabidopsis thaliana* and its expression in *Escherichia coli* and *Saccharomyces cerevisiae*. *Sci Tech Adv Mat* 5:377-381.

- Mattivi F, Guzzon R, Vrhovsek U, Stefanini M, Velasco R (2006) Metabolite profiling of Grape: Flavonols and Anthocyanins. *J Agric Food Chem* 54:7692-7702.
- Mauro MC, Toutaina S, Pinck WL, Ottenc L, Coutos-Thevenotd P, Deloiree A, Barbierd P (1995) High efficiency regeneration of grapevine plants transformed with the GFLV coat protein gene. *Plant Sci* 112:97-106.
- Mazucca P, Ferranti P, Picariello G, Chianese L, Addeo F (2005) Mass spectrometry in the study of anthocyanins and their derivatives: Differentiation of *Vitis vinifera* and hybrid grapes by liquid chromatography/electrospray ionization mass spectrometry and tandem mass spectrometry. *J Mass Spectrom* 40:83-90.
- Medana IM, Hunt NH, Chaudhri G (1997) Tumor necrosis factor expression in the brain during fatal murine cerebral malaria. *Am J Pathol* 150:1473-1486.
- Meyer AS, Yi O-S, Pearson DA, Waterhouse AL, Frankel EN (1997) Inhibition of human low-density lipoprotein oxidation in relation to composition of phenolic antioxidants in grapes (*Vitis vinifera*). *J Agric Food Chem* 45:1638-1643.
- Middleton E, Drzewieki G (1983) Flavonoid inhibition of human basophile histamine release stimulated by various agents. *Biochem Pharmacol* 33:3333-3338.
- Monagas M, Batolome B, Gomez-Cordoves C (2005) Update knowledge about the presence of phenolic compounds in wine. *Crit Rev Food Sci Nutr* 45:85-118.
- Monseles E, Parola AH, Kost D (2003) Low-frequency electromagnetic fields induce a stress effect upon higher plants, as evident by the universal stress signal, alanine. *Biochem Biophys Res Co* 302:427-434.
- Monteiro S, Picarra-Pereira MA, Teixeira AR, Loureiro VB, Ferreira RB (2003) Environmental conditions during vegetative growth determine the major proteins that accumulate in mature grapes. *J Agric Food Chem* 51:4046-4053.
- Moreno IM, González-Weller D, Gutierrez V, Marino M, Cameán AM, González AG, Hardisson A (2008) Determination of Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, Sr, and Zn in red wine samples inductively coupled plasma optical emission spectroscopy: Evaluation of preliminary sample treatments. *Microchem J* 88:56-61.
- Mori M, Tsue H, Tanaka S, Tanaka K, Haddad P (2003) A new and selective capillary column coated with cationic diazocrown ether for separation of organic and inorganic anions by capillary electrophoresis. *Electrophoresis* 24:1944-1950.
- Murch SJ, Rupasinghe HPV, Goodenowe DB, Saxena PK (2004) A metabolomic analysis of medicinal diversity in Huang-qin (*Scutellaria baicalensis*) genotypes: discovery of novel compounds. *Plant Cell Rep* 23:419-25.
- Murphy K, Haudek SB, Thompson M, Giroir BP (1998) Molecular biology of septic shock. *New Horiz* 6:181-93.
- Murray LJ, Lane AJ, Harvey IM, Donovan JL, Nair P, Harvey RF (2002) Inverse relationship between alcohol consumption and active *Helicobacter pylori* infection: the Bristol Helicobacter project. *Am J Gastroenterol* 97:2750-2755.
- Nakagawa H, Kiyozuka Y, Uemura Y, Senzaki H, Shikata N, Hioki K, Tsubura A (2001) Resveratrol inhibits human breast cancer cell growth and may mitigate the effect of linoleic acid, a potent breast cancer cell stimulator. *J Cancer Res Clin* 127:258-264.
- Naugler C, McCallum JL, Klassen G, Strommer J (2007) Concentrations of *trans*-resveratrol and related stilbenes in Nova Scotia wines. *Am J Enol Vitic* 58:117-119.
- Nicholson JK, Lindon JC (2008) Metabonomics. *Nature* 455:1054-1056.
- Nikiforova VJ, Kopka J, Tolstikov V, Fiehn O, Hopkins L, Hawkesford MJ, Hesse H, Hoefgen R (2005) Systems Rebalancing of Metabolism in Response to Sulfur Deprivation, as Revealed by Metabolome Analysis of *Arabidopsis* Plants. *Plant Physiol* 138:304-318.
- Nord LI, Vaag P, Duus J (2004) Quantification of organic and amino acids in Beer by ¹H NMR spectroscopy. *Anal Chem* 76:4790-4798.
- OIV, Organisation Internationale de la Vigne et du Vin, 2nd Edition Of The OIV Descriptor List For Grape Varieties And *Vitis* Species., http://news.reseau-concept.net/pls/news/p_entree?i_sid=&i_type_edition_id=20473&i_section_id=&i_lang=33
- Oksman-Caldentey KM, Inzé D (2004) Plant cell factories in the post-genomic era: new ways to produce designer secondary metabolites. *Trends Plant Sci* 9:433-440.
- Oliveira H, Barros AS, Delgadillo I, Coimbra MA, Santos C (2009) Effects of fungus inoculation and salt stress on physiology and biochemistry of in vitro grapevines: Emphasis on sugar composition changes by FT-IR analyses. *Environ Exp Bot* 65:1-10.
- Oliveira J, Santos-Buelga C, Silva AMS, de Freitas VAP, Mateus N, (2006) Chromatic and structural features of blue anthocyanin-derived pigments present in Port wine. *Anal Chim Acta* 563:2-9.

References

- Opie LH, Lecour S (2007) The red wine hypothesis: from concepts to protective signaling molecules. *Eur Heart J* 28:1683-1693.
- Overman A, Bumrungpert A, Kennedy A, Martínez K, Chuang CC, West T, Dawson B, Jia W, McIntosh M (2010) Polyphenol-rich grape powder extract (GPE) attenuates inflammation in human macrophages and in human adipocytes exposed to macrophage-conditioned media. *Int J Obes* 34:800-808.
- Owen KJ, Green CD, Deverall BJ (2002) A Benzothiadiazole applied to foliage reduces development and egg deposition by *Meloidogyne* spp. in glasshouse-grown grapevine roots. *Australas Plant Path* 31:47-53.
- Pace-Asiak CR, Hahn SE, Diamandis EP, Soleas G, Goldberg DM (1995) The red wine phenolics *trans*-resveratrol and quercetin block human platelet aggregation and eicosanoid synthesis. Implications for protection against coronary heart disease. *Clin Chem Acta* 235:207-219.
- Packer NM (1980) Biosynthesis of acetate-derived phenols (polyketides). In: Stumpf PK (ed) *The Biochemistry of Plants* Vol. 4. Academic Press, New York, pp. 535-570.
- Parker M, Pollnitz AP, Cozzolino D, Francis IL, Herderich J (2007) Identification and quantification of marker compound for 'Pepper' aroma and flavour in Shiraz grape berries by combination of chemometrics and gas chromatography-mass spectrometry. *J Agric Food Chem* 55:5948-5955.
- Patricia TA, Michel C, Guy V, Aziz A (2006) Chitosan stimulates defense reactions in Grapevine leaves and inhibits development of *Botrytis cinerea*. *Eur J Plant Pathol* 114:405-413.
- Pearce F, Befus AD, Bienenstock J (1984) Mucosal mast cells, effects of quercetin and other flavonoids on antigen-induced histamine secretion from rat intestinal mast cells. *J Allergy Clin Immun* 73:819-823.
- Pedroza MA, Zalacain A, Lara JF, Salinas MR (2010) Global grape aroma potential and its individual analysis by SBSE-GC-MS. *Food Res Int* 43:1003-1008.
- Peixe A, Hegewal H, Bohm J, Pais MS, Jacob AP (2004) Preliminary results of trials to improve fungal resistance in Portuguese *Vitis vinifera* cultivars using classical breeding approaches. *Acta Hort* 652:315-319.
- Pellerin P, Vidal S, Williams P, Brillouet J (1995) Characterization of five type II arabinogalactan-protein complexes from red wine with increasing uronic acid content. *Carbohydr Res* 277:135-143.
- Pellerin P, Doco T, Vidal S, Williams P, Brillouet J, O'Neill M (1996) Structural characterization of red wine rhamnogalacturonan II. *Carbohydr Res* 190:183-197.
- Peña RM, Barciela J, Herrero C, García-Martín S (2005) Optimization of solid-phase microextraction methods for GC-MS determination of terpenes in wine. *J Sci Food Agr* 85:1227-1234.
- Pena-Neira A, Hernandez T, Garcia-Vallejo C, Estrella I, Suarez JA (2000) A survey of phenolic compounds in Spanish wines of different geographic origin. *Eur Food Res Technol* 210:445-448.
- Pendurthi UR, Williams JT, Rao LVM (1999) Resveratrol, a polyphenolic compound found in wine, inhibits tissue factor expression in vascular cells. A possible mechanism for the cardiovascular benefits associated with moderate consumption of wine. *Arterioscler Thromb Vasc Biol* 19:419-426.
- Pendurthi UR, Rao LVM (2002) Effect of wine phenolics and stilbene analogues on tissue factor expression in endothelial cells. *Thromb Res* 106:205-211.
- Pereira GE, Gaudellere J-P, Leeuwen CV, Hilbert G, Lavialle O, Maucourt M, Deborde C, Moing A, Rolin D (2005) ¹H NMR chemometrics to characterize mature grape berries in four wine-growing areas in Bordeaux, France. *J Agric Food Chem* 53:6382-6389.
- Pereira GE, Gaudellere J-P, Pieri P, Hilbert G, Maucourt M, Deborde C, Moing A, Rolin D (2006a) Microclimate influence on mineral and metabolic profiles of grape berries. *J Agric Food Chem* 54:6765-6775.
- Pereira GE, Gaudillere J-P, van Leeuwen C, Hilbert G, Maucourt M, Deborde C, Moing A, Rolin D (2006b) ¹H NMR metabolite fingerprints of grape berry: Comparison of vintage and soil effects in Bordeaux grapevine growing areas. *Anal Chim Acta* 563:346-352.
- Pérez-Magariño S, González-San José ML (2006) Polyphenols and colour variability of red wines made from grapes harvested at different ripeness grade. *Food Chem* 96:197-208.
- Perrone G, Nocoletti I, Pascale M, De Rossi A, De Girolamo A, Visconti A (2007) Positive correlation between high levels of ochratoxin A and resveratrol-related compounds in red wines. *J Agric Food Chem* 55:6807-6812.
- Pezet R, Pont V (1990) Ultrastructural observations of Pterostilbene fungitoxicity in dormant conidia of *Botrytis cinerea* Pers. *J Phytopathol* 129:29-30.
- Pezet R, Cuenat P (1996) Resveratrol in wine: extraction from skin during fermentation and post-fermentation standing of must from Gamay grapes. *Am J Enol Viticult* 47:287-290.
- Pezet R, Perret C, Jean-Denis JB, Tabacchi R, Gindro K, Viret O (2003) δ -viniferin, a resveratrol dehydrodimer: one of the major stilbenes synthesized by stressed grapevine leaves. *J Agric Food Chem* 51:5488-5492.

- Pezet R, Gindro K, Viret O, Spring J-L (2004) Glycosylation and oxidative dimerization of resveratrol are respectively associated to sensitivity and resistance of grapevine cultivars to downy mildew. *Physiol Mol Plant Pathol* 65:297-303.
- Pickering GJ, Pour-Nikfardjam MS (2010) Sensory attributes of wine influenced by variety and berry shading discriminated by NMR metabolomics. *Food Chem* 121:1296-1304.
- Pico Y, Kozmutza C (2007) Evaluation of pesticide residue in grape juices and the effect of natural antioxidants on their degradation rate. *Anal Bioanal Chem* 389:1805-1814.
- Poinssot B, Vandelle E, Bentejac M, Adrian M, Levis C, Brygoo Y, Garin J, Sicilia F, Coutos-Thevenot P, Pugin A (2003) The Endopolygalacturonase-1 from *Botrytis cinerea* activates grapevine defense reactions unrelated to its enzymatic activity. *Mol Plant-Microbe Interact* 16:553-564.
- Polesello S, Valsecchi SM (1999) electrochemical detection in the capillary electrophoresis analysis of inorganic compounds. *J Chromatogr A* 834:103-116.
- Pool RM, Creasy LL, Frackelton AS (1981) Resveratrol and the viniferins, their application to screening for disease resistance in grape breeding programs. *Vitis* 20:136-145.
- Possner DRE, Kliever WM (1985) The localization of acids, sugars, potassium and calcium in developing grape berries. *Vitis* 24:229-240.
- Powell PR, Paxon TL, Han KA, Ewing AG (2005) Analysis of biogenic amine variability among individual fly heads with micellar electrokinetic capillary chromatography-electrochemical detection. *Anal Chem* 77:6902-6908.
- Pozo-Bayon MA, Hernandez MT, Martin-Alvarez PJ, Polo MC (2003) Study of low molecular weight phenolic compounds during the aging of sparkling wines manufactured with red and white grape varieties. *J Agric Food Chem* 51:2089-2095.
- Pretorius IS (2000) Tailoring wine yeast for the new millennium: novel approaches to the ancient art of winemaking. *Yeast* 16:675-729
- Pryce RJ, Langcake P (1977) α -Viniferin: An antifungal resveratrol trimer from grapevines. *Phytochemistry* 16:1452-1454.
- Purkayashita RP (1995) Progress in phytoalexin research during the past 50 years. In: Daniel M, Purkayashita RP (eds) *Handbook of Phytoalexin Metabolism and Action*. Marcel Dekker, New York, pp. 1-39.
- Pussa T, Floren J, Kuldepp P, Raal A (2006) Survey of grapevine *Vitis Vinifera* stem polyphenols by liquid chromatography-diode array detection-tandem Mass spectrometry. *J Agric Food Chem* 54:7488-7494.
- Rapp A, Mandery H (1986) Wine aroma. *Experientia* 42:873-880.
- Rapp A, Versini G (1991) Influence of nitrogen compounds in grapes on aroma compounds of wines. In: Rantz J (ed) *International symposium on nitrogen in grapes and wine*. American Society for Enology and Viticulture. Davis, CA, pp. 156-164.
- Ratcliffe RG, Shachar-Hill Y (2005) Revealing metabolic phenotypes in plants: inputs from NMR analysis. *Biol Rev* 80:27-43.
- Reglinski T, Elmer PAG, Taylor JT, Parry FJ, Marsden R, Wood PN (2005) Suppression of Botrytis bunch rot in Chardonnay grapevines by induction of host resistance and fungal antagonism. *Australas Plant Pathol* 34:481-488.
- Reid LM, O'Donnell CP, Downey G (2004) Potential of SPME-GC and chemometrics to detect adulteration of soft fruit purees. *J Agric Food Chem* 52:421-7.
- Renault AS, Deloire A, Bierne J (1996) Pathogenesis-related proteins in grapevines induced by salicylic acid and *Botrytis cinerea*. *Vitis* 35:49-52.
- Repka V, Fischerova I, Silharova K (2004) Methyl jasmonate is a potent elicitor of multiple defense responses in grapevine leaves and cell-suspension cultures. *Biol Plantarum* 48:273-283.
- Ribereau-Gayon P, Glories Y, Maujean A, Dubourdiou D (2000) *Handbook of enology Vol. 2*. John Wiley & Sons, New York.
- Ricardo-Da-Silva JM, Cheynier V, Samson A, Bourzeix M (1993) Effect of pomace contact, carbonic maceration, and hyperoxidation on the procyanidin composition of Grenach Blanc wines. *Am J Enol Vitic* 44: 168-172.
- Riou V, Vernhet A, Doco T, Moutounet M (2002) Aggregation of grape seed tanins in model wine-effect of wine polysaccharides. *Food Hydrocolloid* 16:17-23.
- Rivera L, Morón R, Sánchez M, Zarzuelo A, Galisteo M (2008) Quercetin ameliorates metabolic syndrome and improves the inflammatory status in obese Zucker rats. *Obesity* 16:2081-2087.
- Robert N, Roche K, Lebeau Y, Breda C, Boulay M, Esnault R, Buffard D (2002) Expression of grapevine chitinase genes in berries and leaves infected by fungal or bacterial pathogens. *Plant Sci* 162:389-400.
- Robinson SP, Jacobs AK, Dry IB (1997) A class IV chitinase is highly expressed in grape berries during ripening. *Plant Physiol* 114:771-778.
- Robinson SP, Davies C (2000) Molecular biology of grape berry ripening. *Aust J Grape Wine Res* 6:175-188.

References

- Rochfort S, Ezernieks V, Bastian SEP, Downey MO (2010) Sensory attributes of wine influenced by variety and berry shading discriminated by NMR metabolomics. *Food Chem* 121:1296-1304.
- Rodríguez-Delgado MA, González-Hernández G, Conde-González JE, Pérez-Trujillo JP (2002) Principal component analysis of the polyphenol content in young red wines. *Food Chem* 78:523-532.
- Roessner U, Luedemann A, Burst D, Fiehn O, Linke T, Willmitzer L, Fernie AR (2001) Metabolic profiling allows comprehensive phenotyping of genetically or environmentally modified plant systems. *Plant Cell* 13:11-29.
- Roggero JP, Garcia-Parrilla C (1995) Effects of ultraviolet irradiation on resveratrol and changes in resveratrol and various of its derivatives in the skins of ripening grapes. *Sciences des Aliments* 15:411-422.
- Romanazzi G, Nigro E, Ippolito A, Di-Venere D, Salerno M (2002) Effects of pre- and postharvest chitosan treatments to control storage grey mold of table grapes. *J Food Sci* 67:1862-1867.
- Romano P, Suzzi G, Brandolini V, Menziani E, Domizio P (1996) Determination of 2,3-butanediol in high and low acetoin producers of *Saccharomyces cerevisiae* wine yeast by automated multiple development (AMD). *Lett Appl Microbiol* 22:299-302.
- Roos G, Roeseler C, Bueter KB, Simmen U (2004) Classification and correlation of St. John Wort extracts by nuclear magnetic resonance spectroscopy, multivariate data analysis and pharmacological activity. *Planta Med* 70:771-777.
- Rosslenbroich HJ, Stuebler D (2000) *Botrytis cinerea* – history of chemical control and novel fungicides for its management. *Crop Prot* 19:557-561.
- Rostás M, Bennett R, Hilker M (2002) Comparative Physiological Responses in Chinese Cabbage Induced by Herbivory and Fungal Infection. *J Chem Ecol* 28:2449-2463.
- Ruberto G, Renda A, Amico V, Tringali C (2008) Volatile components of grape pomaces from different cultivars of Sicilian *Vitis vinifera* L. *Bioresource Technol* 99:260-268.
- Ryan D, Robards K (2006) Metabolomics: the greatest omics of them all? *Anal Chem* 78:7954-7958.
- Saeed AI, White VSJ, Li L, Liang W, Bhagabati N, Braisted J, Klapa M, Currier T, Thiagarajan M, Sturn A, Snuffin M, Rezantsev A, Popov D, Ryltsov A, Kostukovich E, Borisovsky I, Liu Z, Vinsavich A, Trush V, Quackenbush J (2003) TM4: A free, open-source system for microarray data management and analysis. *Biotechniques* 34:274-278.
- Saito M, Hosoyama H, Ariga T, Kataoka S, Yamaji N (1998) Antiulcer activity of grape seed extract and procyanidins. *J Agric Food Chem* 46:1460-1464.
- Saito S, Takeuchi S, Yoshimoto K, Maeda M, Aoyama M (2007) Direct fluorescence detection of ultratrace lanthanide(III) ions complexed with aromatic polyaminocarboxylate, avoiding quenching of ligand-centered emission, using capillary zone electrophoresis with a ternary complexing technique. *Analyst* 132:237-241.
- Sajjadi F, Takabayashi K, Foster A, Domingo RC, Firestein G (1996) Inhibition of TNF-alpha expression by adenosine: role of A₃ adenosine receptors. *J Immunol* 156:3435-3442.
- Salzman RA, Tikhonova I, Bordelon BP, Hasegawa PM, Bressan RA (1998) Coordinate accumulation of antifungal proteins and hexose constitutes a developmentally controlled defense response during fruit ripening in grape. *Plant Physiol* 117:465-472.
- Sánchez-Palomo E, Díaz-Moroto MC, Pérez-Coello MS (2005) Rapid determination of volatile compounds in grapes by HS-SPME coupled with GC-MS. *Talanta* 66:1152-1157.
- Sarig P, Zutkhi Y, Lisker N, Shkelerman Y, Ben-Arie R, Bielski R, Laing W, Clark C (1998) Natural and induced resistance of table grapes to bunch rots. *Acta Hort* 464:65-70.
- Sarrazin E, Dubourdieu D, Darriet P (2007) Characterization of key-aroma compounds of botrytized wines, influence of grape botrytization. *Food Chem* 103:536-545.
- Sato M, Maulik G, Ray PS, Bagchi D, Das DK (1999) Cardioprotective effects of grape seed proanthocyanidin against ischemic reperfusion injury. *J Mol Cell Cardiol* 31:1289-1297.
- Sato M, Bagchi D, Tosaki A, Das DK (2001) Grape seed proanthocyanidin reduces cardiomyocyte apoptosis by inhibiting ischemia/reperfusion-induced activation of JNK-1 and CJUN. *Free Radical Bio Med* 31:729-737.
- Sato S, Soga T, Nishioka T, Tomita M (2004) Simultaneous determination of the main metabolites in rice leaves using capillary electrophoresis mass spectrometry and capillary electrophoresis diode array detection. *Plant J* 40:151-63.
- Savant RH, Banerjee K, Utture SC, Patil SH, Dasgupta A, Ghaste MS, Adsule PG (2010) Multiresidue analysis of 50 pesticides in grape, pomegranate, and mango by gas chromatography-ion trap mass spectrometry. *J Agric Food Chem* 58:1447-1454.
- Sbaghi M, Jeandet P, Faivre B, Bessis R, Fournieux JC (1995) Development of methods using phytoalexin (resveratrol) assessment as a selection criterion to screen grapevine *in vitro* cultures for resistance to grey mould (*Botrytis cinerea*). *Euphytica* 86:41-47.

- Schnee S, Viret O, Gindro K (2008) Role of stilbene in the resistance of grapevine to powdery mildew. *Physiol Mol Plant Pathol* 72:128-133.
- Schneider Y, Chabert P, Stutzmann J, Coelho D, Fougerousse A, Gosse F, Launay JF, Brouillard R, Raul F (2003) Resveratrol analog (Z)-3,5,4'-tri-methoxystilbene is a potent anti mitotic drug inhibiting tubulin polymerization. *Int J Cancer* 107:189-196.
- Schneider Y, Fischer B, Coelho D, Roussi S, Gosse F, Pierre B, Raul F (2004) (Z)-3,5,4'-tri-O-methyl-resveratrol, induces apoptosis in human lymphoblastoid cells independently of their p53 status. *Cancer Lett* 211:155-161.
- Schoefer L, Braune A, Blaut M (2001) A fluorescence quenching test for the detection of flavonoid transformation. *FEMS Microbiol Lett* 204:277-280.
- Schripsema J (2010) Application of NMR in plant metabolomics: Techniques, problems and prospects. *Phytochem Anal* 21:14-21.
- Schwab W, Rachel DR, Lewinsohn E (2008) Biosynthesis of plant-derived flavor compounds. *Plant J* 54:712-732.
- Schwarz M, Jerz G, Winterhalter P (2003) Isolation and structure of Pinotin A, a new anthocyanin derivative from Pinotage wine. *Vitis* 42:105-106.
- Sefc KM, Lopes MS, Lefort F, Botta R, Roubelakis-Angelakis KA, Ibáñez J, Pejic I, Wagner HW, Glössl J, Steinkellner H (2000) Microsatellite variability in grapevine cultivars from different European regions and evaluation of assignment testing to assess the geographic origin of cultivars. *Theor Appl Genet* 100:498-505.
- Seymour EM, Singer AA, Bennink MR, Parikh RV, Kirakosyan A, Kaufman PB, Bolling SF (2008) Chronic intake of a phytochemical-enriched diet reduces cardiac fibrosis and diastolic dysfunction caused by prolonged salt-sensitive hypertension. *J Gerontol A Biol Sci Med Sci* 63:1034-1042.
- Shadle GL, Wesley SV, Korth KL, Chen F, Lamb C, Dixon RA (2003) Phenylpropanoid compounds and disease resistance in transgenic tobacco with altered expression of L-phenylalanine ammonia-lyase. *Phytochemistry* 64:153-161.
- Shi J, Yu J, Pohorly JE, Kakuda Y (2003) Polyphenolics in grape seeds-Biochemistry and functionality. *J Med Food* 6:291-299.
- Silva RC, Darmon N, Fernandez Y, Mitjavila S (1991) Oxygen free radical scavenger capacity in aqueous models of different procyanidins from grape seeds. *J Agric Food Chem* 39:1549-1552.
- Simó C, Barbas C, Cifuentes A (2003) Chiral electromigration methods in food analysis. *Electrophoresis* 24:2431-2441.
- Singleton VL (1982) Grape and wine phenolics; background and prospects. In: Webb AD (ed) Proceedings of the University of California, Davis, Grape and Wine Centennial Symposium. University of California Press, Davis, pp. 215-227.
- Singleton VL, Zaya J, Trousdale EK (1986) Caftaric and coumaric acids in fruit of *Vitis*. *Phytochemistry* 25:2127-2133.
- Sladkovsky R, Solich P, Urbanek M (2004) High Performance Liquid Chromatography determination of phenolic compounds in wine using off-line Isotachophoretic pre-treatment. *J Chromatogr A* 1040:179-184.
- Slaughter AR, Hamiduzzaman MM, Gindro K, Neuhaus J-M, Mauch-Mani B (2008) β -aminobutyric acid-induced resistance in grapevine against downy mildew: involvement of pterostilbene. *Eur J Plant Pathol* 122:185-195.
- Sobolev AP, Segre A, Lamanna R (2003) Proton high-field NMR study of tomato juice. *Magn Reson Chem* 41:237-245.
- Soga T, Ohashi Y, Ueno Y, Naraoka H, Tomita M, Nishioka T (2003) Quantitative metabolome analysis using capillary electrophoresis mass spectrometry. *J Proteome Res* 2:488-494.
- Soleas GJ, Goldberg DM, Grass L, Levesque M, Diamandis EP (2001) Do wine polyphenols modulate p53 gene expression in human cancer lines? *Clin Biochem* 34:415-420.
- Son H-S, Kim KM, van den Berg F, Hwang G-S, Park W-M, Lee C-H, Hong Y-S (2008) ^1H Nuclear magnetic resonance-based metabolomic characterization of wines by grape varieties and production areas. *J Agric Food Chem* 56:8007-8016.
- Son H-S, Hwang G-S, Kim KM, Ahn H-J, Park W-M, van den Berg F, Hong Y-S, Lee C-H (2009a) Metabolomic studies on geographical grapes and their wines using ^1H NMR analysis coupled with multivariate statistics. *J Agric Food Chem* 57:1481-1490.
- Son H-S, Hwang G-S, Kim KM, Kim E-Y, van den Berg F, Park W-M, Lee C-H, Hong Y-S (2009b) ^1H NMR-based metabolomic approach for understanding the fermentation behaviors of wine yeast strains. *Anal Chem* 81:1137-1145.
- Sovak M (2001) Grape extract, Resveratrol, and its analogs: A Review. *J Med Food* 4:93-105.

References

- Sponholz WR (1988) Alcohols derived from sugars and other sources and fullbodiedness of wines. In: Liskens JF, Jackson JF (eds) Wine Analysis. Springer-Verlag, Berlin, pp. 147-172.
- Stervbo U, Vang O, Bonnesen C (2007) A review of the content of putative chemopreventive phytoalexin resveratrol in red wine. *Food Chem* 101:449-457.
- Stewart LK, Soileau JL, Ribnicky D, Wang ZQ, Raskin I, Poulev A, Majewski M, Cefalu WT, Gettys TW (2008) Quercetin transiently increases energy expenditure but persistently decreases circulating markers of inflammation in C57BL/6J mice fed a high-fat diet. *Metabolism* 57:S39-S46.
- Stines AP, Grubb J, Gokowiak H, Henschke P, Hoj PB, Heewijk RV (2000) Proline and arginine accumulation in developing berries of *Vitis vinifera* L. in Australian vineyards: Influence of vine cultivar, berry maturity and tissue type. *Aust J Grape Wine Res* 6:150-158.
- Student (1908) The probable error of a mean. *Biometrika* 6:1-25.
- Sumner LW, Mendes P, Dixon R (2003) Plant metabolomics: large-scale phytochemistry in the functional genomics era. *Phytochemistry* 62:817-83.
- Sun BS, Ferrão C, Spranger MI (2003) Effect of wine style and winemaking technology on resveratrol level in wines. *Cienc Tec Vitivinic* 18:77-91.
- Sun BS, Spranger MI (2005) quantitative extraction and analysis of grape and wine proanthocyanidins and stilbenes. *Ciencia e Tecnica Vitivinicola* 20:59-89.
- Sun BS, Ribes A, Leandro MC, Belchior AP, Spranger MI (2006) Stilbenes: quantitative extraction from grape skins, contribution of grape solids to wine and variation during wine maturation. *Anal Chim Acta* 563:382-390.
- Swanson CA, Elshishiny EDH (1958) Translocation of sugars in the Concord grape. *Plant Physiol* 33:33-37.
- Takkouche B, Regueira-Mendez C, Garcia-Closas R, Figueiras A, Gestal-Otero JJ, Hernán MA (2002) Intake of wine, beer, and spirits and the risk of clinical common cold. *Am J Epidemiol* 155:853-858.
- Talcott S, Lee J (2002) Ellagic acid and flavonoid antioxidant content of muscadine wine and juice. *J Agric Food Chem* 50:3186-3192.
- Tanaka Y, Sasaki N, Ohmiya A (2008) Biosynthesis of plant pigments: anthocyanins, betalains and carotenoids. *Plant J* 54:733-749.
- Tattersall DB, van Heeswijck R, Hoj PB (1997) Identification and characterization of a fruit-specific, thaumatin-like protein that accumulates at very high levels in conjunction with the onset of sugar accumulation and berry softening in grapes. *Plant Physiol* 114:759-769.
- Tebib K, Besancon P, Rouanet J (1996) Effects of dietary grape seed tannins on rat cecal fermentation and colonic bacterial enzymes. *Nutr Res* 16:105-110.
- Tedesco I, Russo M, Russo P, Iacomino G, Russo GL, Carraturo A, Faruolo C, Moio L, Palumbo R (2000) Antioxidant effect of red wine polyphenols on red blood cells. *J Nutr Biochem* 11:114-119.
- Teissedre PL, Frankel EN, Waterhouse AL, Peleg H, German JB (1996) Inhibition of *in vitro* human LDL oxidation by phenolic antioxidants from grapes and wines. *J Sci Food Agric* 70:55-61.
- This P, Lacombe T, Thomas MR (2006) Historical origins and genetic diversity of wine grapes. *Trends Genet* 22:511-519.
- Thomas MR, Matsumoto S, Cain P, Scott NS (1993) Repetitive DNA of Grappegvine: classes present and sequences suitable for cultivar identification. *Theor Appl Genet* 86:173-180.
- Tianniam S, Tarachiwin L, Bamba T, Kobayashi A, Fukusaki E (2008) Metabolic profiling of *Angelica acutiloba* roots utilizing gas chromatography time of flight mass spectrometry for quality assessment based on cultivation area and cultivar via multivariate pattern recognition. *J Biosci Bioeng* 105:655-659.
- Tohge T, Nishiyama Y, Hirai MY, Yano M, Nakajima JI, Awazuhara M, Inoue E, Takahashi H, Goodenowe DB, Kitayama M, Noji M, Yamazaki M, Saito K (2005) Functional genomics by integrated analysis of metabolome and transcriptome of *Arabidopsis* plants over-expressing an MYB transcription factor. *Plant J* 42:218-235.
- Tracey MD, Kevin J, Anthony C (1994) Tumor necrosis factor: A pleiotropic cytokine and therapeutic target. *Ann Rev Med* 45:491-503.
- Trethewey RN, Krotzky AJ, Willmitzer L (1999) Metabolic profiling: a Rosetta stone for genomics? *Curr Opin Plant Biol* 2:83-5.
- Trygg J, Wold S (2002) Orthogonal projections to latent structures (O-PLS). *J Chemom* 16:119-128.
- Trygg J, Wold S (2003) O2-PLS, a two-block (X-Y) latent variable regression (LVR) method with an integral OSC filter. *J Chemom* 17:53-64.
- Tsvetkov II, Atanassov AI, Tsovala VM (2000) Gene transfer for stress resistance in grapes. *Acta Hort* 528:389-396.
- Tyagi A, Agarwal R, Agarwal C (2003) Grape seed extract inhibits EGF-induced and constitutively active mitogenic signaling but activates JNK in human prostate carcinoma DU145 cells: possible role in antiproliferation and apoptosis. *Oncogene* 22:1302-1316.

- Uchida S (1980) Condensed tannins scavenging active oxygen radicals. *Med Sci Res* 15:831–832.
- van Beilen JB, Poirier Y (2008) Production of renewable polymers from crop plants. *Plant J* 54:684-701.
- van der Greef J, Smilde AK (2005) Symbiosis of chemometrics and metabolomics: past, present and future. *J Chemometr* 19:376-386.
- van der Kooy F, Maltese F, Choi YH, Kim HK, Verpoorte R (2009) Quality control of herbal material and phytopharmaceuticals with MS and NMR based metabolic fingerprinting. *Planta Med* 75:763-775.
- Vandaveer IV WR, Pasas SA, Martin RS, Lunte SM (2002) Recent developments in amperometric detection for microchip capillary electrophoresis. *Electrophoresis* 23:3667–3677.
- Vanhoenacker G, De Villiers A, Lazou K, D Keukeleire D, Sandra P (2001) Comparison of high performance liquid chromatography – mass spectroscopy and capillary electrophoresis – mass spectroscopy for the analysis of phenolic compounds in diethyl ether extracts of red wines. *Chromatographia* 54:309-315.
- Venkateswarlu P, Mohan KR, Kumar CR, Seshiah K (2007) Monitoring of multi-class pesticide in fresh grape samples using liquid chromatography with electrospray tandem mass spectrometry. *Food Chem* 105:1760-1766.
- Verhoeven HA, de Vos CHR, Bino RJ, Hall RD (2006) Plant Metabolomics strategies based upon Quadruple Time of Flight Mass Spectrometry (QTOF-MS). In: Saito K, Dixon R, Willmitzer L (eds) *Plant Metabolomics*, Springer Verlag, Heidelberg.
- Verpoorte R, Memelink J (2002) Engineering secondary metabolite production in plants. *Curr Opin Biotechnol* 13:181-7.
- Verpoorte R, Choi YH, Mustafa NR, Kim HK (2008) Metabolomics: back to basics. *Phytochem Rev* 7:525-537.
- Verpoorte R, Choi YH, Kim HK (2010) Metabolomics: what's new? *Flavour Fragr. J.* 25:128-131.
- Vezzulli S, Civardi S, Ferrari F, Bavaresco L (2007) Methyl Jasmonate treatment as a trigger of Resveratrol synthesis in cultivated Grapevine. *Am J Enol Viticult* 58:530-533.
- Vial J, Pezous B, Thiébaud D, Sassi P, Teillet B, Cahours X, Rivals I (2011) The discriminant pixel approach: A new tool for rational interpretation of GCxGC-MS chromatograms. *Talanta* 83: 1295-1301.
- Viant MR (2003) Improved methods for acquisition and interpretation of NMR metabolomic data. *Biochem Biophys Res Comm* 310:943-948.
- Vidal S, Doco T, Williams P, Pellerin P, York WS, O'Neill MA, Glushka J, Darvill AG, Albersheim P (2000) Structural characterization of the pectic polysaccharide rhamnogalacturonan II: evidence for the backbone location of the aceric acid-containing oligoglycosyl side chain. *Carbohydr Res* 326:277–294.
- Vidal S, Hayasaka Y, Meudec E, Cheynier V, Skouroumounis G (2004) Fractionation of Grape Anthocyanin Classes Using Multilayer Coil Countercurrent Chromatography with Step Gradient Elution. *J Agric Food Chem* 52:713-719.
- Vidal JR, Kikkert JR, Malnoy MA, Wallace PG, Barnard J, Reisch BI (2006) Evaluation of transgenic 'Chardonnay' (*Vitis vinifera*) containing magainin genes for resistance to crown gall and powdery mildew. *Transgenic Res* 15:69-82.
- Viggiani L, Morelli MAC (2008) Characterization of wines by nuclear magnetic resonance: A work study on wines from the Basilicata region in Italy. *J Agric Food Chem* 56:8273-827.
- Vilanova M, Cortés S, Santiago JL, Martínez C, Fernández E (2007) Aromatic compounds in wine produced during fermentation: Effect of three red cultivars. *Int J Food Prop* 10:867-875.
- Vilcek J, Lee TH (1991) Tumor necrosis factor. *J Biol Chem* 266:7313-7316.
- Vitrac X, Bornet A, Vanderlinde R, Valls J, Richard T, Delaunay, J -C, Merillon J -M, Teissedre P -L (2005) Determination of stilbenes (δ -viniferin, *trans*-astringin, *trans*-piceid, *cis*- and *trans*-resveratrol, ϵ -viniferin) in brazilian wines. *J Agric Food Chem* 53:5664-5669.
- Vivier MA, Pretorius IS (2000) Genetic improvement of grapevine: tailoring grape varieties for the third millennium. *S Afr J Enol Vitic* 21:5–26.
- Vivier MA, Pretorius IS (2002) Genetically tailored grapevine for the wine industry. *Trends Biotechnol* 20:472-478.
- Vogels N, Nijts IMT, Westerterp-Plantenga MS (2004) The effect of grape seed extract on 24 h energy intake in humans. *Eur J Clin Nutr* 58:667-673.
- von Roepenack-Lahaye 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.
- Wallace CHR, Baczko I, Jones L, Fercho M, Light PE (2006) Inhibition of cardiac voltage-gated sodium channels by grape polyphenols. *Brit J Pharmacol* 149:657-665.
- Wang H, Race EJ, Shrikhande AJ (2003) Characterization of anthocyanins in grape juices by ion trap liquid chromatography-mass spectrometry. *J Agric Food Chem* 51:1839-1844.

References

- Wang Y, Catana F, Yang Y, Roderick R, van Beemen RB (2002) An LC-MS method for analyzing total resveratrol in grape juice, cranberry juice and in wine. *J Agric Food Chem* 50:431-435.
- Ward J (1968) Hierarchical grouping to optimize an objective function. *J Am Stat Assoc* 58:236-244.
- Waterhouse AL (2002) Wine phenolics. *Ann. N.Y. Acad. Sci.* 957:21-36.
- Waters EJ, Hayasaka Y, Tattersall DB, Adams KS, Williams PJ (1998) Sequence analysis of grape (*Vitis vinifera*) berry chitinases that cause haze formation in wines. *J Agric Food Chem* 46:4950-4957.
- Wenguang J, Wenlai F, Yan X, Guang'ao Z, Jiming L, Ying Y (2007) Analysis of free terpenoids in *Vitis vinifera* using solvent assisted flavour evaporation and gas chromatography-tandem mass spectrometry. *Chin J Chromatogr* 25:881-886.
- Williams AA, Rosser PR (1981) Aroma enhancing effects of ethanol. *Chem Senses* 6:149-153.
- Wu Q, Wang M, Simon JE (2005) Determination of proanthocyanidins in fresh grapes and grape products using liquid chromatography with mass spectrometric detection. *Rapid Commun Mass Sp* 19:2062-2068.
- Yamamoto T, Iketani H, Ieki H, Nishizawa Y, Notsuka K, Hibi T, Hayashi T, Matsuta N (2000) Transgenic grapevine plants expressing a rice chitinase with enhanced resistance to fungal pathogens. *Plant Cell Rep* 19:639-646
- Yilmaz Y, Toledo RT (2004) Health aspects of functional grape seed constituents. *Trends Food Sci Tech* 15:422-433.
- Yuan-Yuan D, Guo-Yun B, Xu Z, Mai-Li L (2007) Classification of wines based on combination of ¹H NMR spectroscopy and principal component analysis. *Chin J Chem* 25:930-936.
- Yunoki K, Yasui Y, Hirose S, Ohnishi M (2005) Fatty acids in must prepared from 11 grapes grown in Japan: Comparison with wine and effect on fatty acid ethyl ester formation. *Lipids* 40:361-367.
- Zern TL, Wood RJ, Greene C, West KL, Liu Y, Aggarwal D, Shachter NS, Fernandez ML (2005) Grape polyphenols exerts a cardioprotective effect in pre- and postmenopausal women by lowering plasma lipids and reducing oxidative stress. *J Nutr* 135:1911-1917.
- Zhang L, Kai G, Lu B, Zhang H, Tang K, Jiang J, Chen W (2005) Metabolic engineering of Tropane alkaloid biosynthesis in plants. *J Integ Plant Biotechnol* 47:136-143.
- Zhao XL, Li JD, Shi YL, Cai YQ, Mou SF, Jiang JB (2007) Determination of perfluorinated compounds in waste water and river water samples by mixed hemimicelle-based solid-phase extraction before liquid chromatography-electrospray tandem mass spectrometry detection. *J Chromatogr A* 1154:52-59.
- Zou A-M, Chen ML, Chen X-W, Wang J-H (2007) Cell-sorption of paramagnetic metal ions on a cell-immobilized micro-column in the presence of an external magnetic field. *Anal Chim Acta* 598:74-81.
- Zulak KG, Weljie AM, Vogel HJ, Facchini PJ (2008) Quantitative ¹H NMR metabolomics reveals extensive metabolic reprogramming of primary and secondary metabolism in elicitor-treated opium poppy cell cultures. *BMC Plant Biol* 8:5.