# Processing and Impact on Antioxidants in Beverages

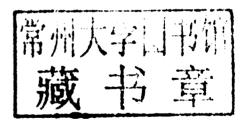




# PROCESSING AND IMPACT ON ANTIOXIDANTS IN BEVERAGES

Editor

VICTOR PREEDY King's College London, London, UK







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# PROCESSING AND IMPACT ON ANTIOXIDANTS IN BEVERAGES

### List of Contributors

- **Adelin Albert** Department of Medical Informatics and Biostatistics B23, University of Liège, CHU Sart Tilman, Liège, Belgium
- Harunobu Amagase FreeLife International, Phoenix, AZ, USA
- **Miryam Amigo-Benavent** Department of Nutrition and Metabolism, Institute of Food Science and Technology and Nutrition (ICTAN-CSIC), Madrid, Spain
- Wilfried Andlauer Institute of Life Technologies, University of Applied Sciences Valais, Sion, Switzerland
- Reşat Apak Istanbul University, Faculty of Engineering, Department of Chemistry, Avcilar, Istanbul, Turkey
- M. Fátima Barroso REQUIMTE, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto, Porto, Portugal
- Burcu Bekdeşer Istanbul University, Istanbul, Turkey
- **Ana Belščak-Cvitanović** Department of Food Engineering, Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva, Zagreb, Croatia
- Mustafa Bener Istanbul University, Istanbul, Turkey
- **Kleber Berté** Graduate Program of Food Engineering PPGEAL, Chemical Engineering Department, Federal University of Paraná (UFPR), Curitiba, PR, Brazil
- **Joshua A. Bomser** Department of Human Sciences, The Ohio State University, Columbus, OH, USA
- **Oreste V. Brenna** Department of Food, Environmental and Nutritional Sciences, University of Milan, Milan, Italy
- **Richard S. Bruno** Department of Human Sciences, The Ohio State University, Columbus, OH, USA
- Arijana Bušić Department of Food Engineering, Faculty of Food Technology and Biotechnology, University of Zagreb, Zagreb, Croatia
- María D. Busto Department of Biotechnology and Food Science, Area of Biochemistry and Molecular Biology, University of Burgos, Burgos, Spain
- **Cristian Calderón** Facultad de Química y Biología, Universidad de Santiago de Chile, Santiago Chile
- M. Camenzuli Australian Centre for Research on Separation Science (ACROSS), School of Science and Health, University of Western Sydney (Parramatta), Sydney, NSW, Australia
- **Ana Maria Campos** Facultad de Química y Biología, Universidad de Santiago de Chile, Santiago Chile
- Mª. Dolores del Castillo Food Bioscience Group, Department of Food Bioactivity and Analysis, Institute of Food Science Research (CSIC-UAM), Madrid, Spain

- **Mónica Cavia-Saiz** Department of Biotechnology and Food Science, Area of Biochemistry and Molecular Biology, University of Burgos, Burgos, Spain
- **Luísa Correia-Sá** REQUIMTE, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto, Porto, Portugal
- Chiara Dall'Asta Department of Food Science, University of Parma, Parma, Italy
- Nadia Dardenne Department of Medical Informatics and Biostatistics B23, University of Liège, CHU Sart Tilman, Liège, Belgium
- Dalene de Beer Post-Harvest & Wine Technology Division, Agricultural Research Council, Infruitec-Nietvoorbij Institute, Stellenbosch, South Africa
- Jean-Olivier Defraigne CREDEC, University of Liège, CHU Sart Tilman, Liège, Belgium
- Cristina Delerue-Matos REQUIMTE, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto, Porto, Portugal
- **Gui-Fang Deng** Guangdong Provincial Key Laboratory of Food, Nutrition and Health, Department of Nutrition, School of Public Health, Sun Yat-Sen University, Guangzhou, China
- G.R. Dennis Australian Centre for Research on Separation Science (ACROSS), School of Science and Health, University of Western Sydney (Parramatta), Sydney, NSW, Australia
- Valentina F. Domingues REQUIMTE, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto, Porto, Portugal
- Jacques Dommes Plant Molecular Biology and Biotechnology B22, University of Liège, Plant Biology Institute, Sart Tilman, Liège, Belgium
- Sandra A.V. Eremia National Institute for Biological Sciences, Bucharest, Romania
- M.L. Fernández de Córdova Department of Physical and Analytical Chemistry, University of Jaén, Jaén, Spain
- **Isabel M.P.L.V.O. Ferreira** REQUIMTE, Laboratório de Bromatologia e Hidrologia, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Porto, Portugal,
- Mario G. Ferruzzi Department of Food Science, Purdue University, West Lafayette, IN, USA
- **Gianni Galaverna** Department of Food Science, University of Parma, Parma, Italy
- Cristina García-Viguera Phytochemistry Laboratory, Department of Food Science and Technology, CEBAS-CSIC, Espinardo, Murcia, Spain

- Ramón Gervilla Departamento de Ciencia Animal y de los Alimentos, Universitat Autònoma de Barcelona, Edificio V. Campus de la UAB, Cerdanyola del Vallès, Spain
- Bernard A. Goodman State Key Laboratory for Conservation and Utilization of Subtropical Agro-Bioresources, Guangxi University, Nanning, Guangxi, China
- Kubilay Güçlü Istanbul University, Istanbul, Turkey
- Rosemary Hoffmann-Ribani Graduate Program of Food Engineering – PPGEAL, Chemical Engineering Department, Federal University of Paraná (UFPR), Curitiba, PR, Brazil
- Shiromani Jayasekera Riddet Institute, Massey University, Palmerston North, New Zealand
- Elizabeth Joubert Post-Harvest & Wine Technology Division, Agricultural Research Council, Infruitec-Nietvoorbij Institute, Stellenbosch, South Africa
- Lovedeep Kaur Riddet Institute, Massey University, Palmerston North, New Zealand
- Claire Kevers Plant Molecular Biology and Biotechnology B22, University of Liège, Plant Biology Institute, Sart Tilman, Liège, Belgium
- **Draženka Komes** Department of Food Engineering, Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva, Zagreb, Croatia
- Agnieszka Kosińska Division of Food Sciences, Institute of Animal Reproduction and Food Research of the Polish Academy of Sciences, Olsztyn, Poland; Institute of Life Technologies, University of Applied Sciences Valais, Sion, Switzerland
- **Hua-Bin Li** Guangdong Provincial Key Laboratory of Food, Nutrition and Health, Department of Nutrition, School of Public Health, Sun Yat-Sen University, Guangzhou, China
- Sha Li Guangdong Provincial Key Laboratory of Food, Nutrition and Health, Department of Nutrition, School of Public Health, Sun Yat-Sen University, Guangzhou, China
- **Shu-Ke Li** Guangdong Provincial Key Laboratory of Food, Nutrition and Health, Department of Nutrition, School of Public Health, Sun Yat-Sen University, Guangzhou, China
- **Eduardo Lissi** Facultad de Química y Biología, Universidad de Santiago de Chile, Santiago Chile
- **Simona Carmen Litescu** National Institute for Biological Sciences, Bucharest, Romania
- **Sergio Lobato** Facultad de Química y Biología, Universidad de Santiago de Chile, Santiago Chile
- **Camilo López-Alarcón** Pontificia Universidad Católica de Chile, Santiago, Chile
- **Agenor Maccari, Junior** Chemical Engineering Department, Federal University of Paraná (UFPR), Curitiba, PR, Brazil
- Nuria Martí Instituto de Biología Molecular y Celular, Universidad Miguel Hernández, Elche, Alicante, Spain
- **Pedro Mena** Phytochemistry Laboratory, Department of Food Science and Technology, CEBAS-CSIC, Espinardo, Murcia, Spain

- **Liuping Miao** Shanghai Institute of Pharmaceutical Industry, State Key Laboratory of New Drug & Pharmaceutical Process, Shanghai, China
- Paul J. Moughan Riddet Institute, Massey University, Palmerston North, New Zealand
- Pilar Muñiz Department of Biotechnology and Food Science, Area of Biochemistry and Molecular Biology, University of Burgos, Burgos, Spain
- **C.S. Murugesh** Academy of Scientific and Innovative Research, and Food Engineering Department, CSIR-Central Food Technological Research Institute, Mysore, India
- Anita Oberholster Department of Viticulture and Enology, University of California, Davis, CA, USA
- M.B.P.P. Oliveira REQUIMTE, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Porto, Portugal
- **Sebastian E.W. Opitz** Zurich University of Applied Sciences, Institute of Chemistry and Biological Chemistry, Wädenswil, Switzerland
- Natividad Ortega Department of Biotechnology and Food Science, Area of Biochemistry and Molecular Biology, University of Burgos, Burgos, Spain
- Mustafa Özyürek Istanbul University, Istanbul, Turkey
- M. Trinidad Pérez-Palacios Tecnología de los Alimentos, Facultad de Veterinaria, Universidad de Extremadura, Cáceres, Spain
- Joël Pincemail CREDEC, University of Liège, CHU Sart Tilman, Liège, Belgium
- Alexandra Plácido REQUIMTE, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto, Porto, Portugal
- Gabriel-Lucian Radu National Institute for Biological Sciences, Bucharest, Romania
- H.J. Ritchie Thermo Fisher Scientific, Runcorn, UK
- Délia B. Rodriguez-Amaya Faculty of Food Engineering, University of Campinas – UNICAMP, Department of Food Science, Campinas, SP, Brazil
- A. Ruiz Medina Department of Physical and Analytical Chemistry, University of Jaén, Jaén, Spain
- Jordi Saldo Departamento de Ciencia Animal y de los Alimentos, Universitat Autònoma de Barcelona, Edificio V. Campus de la UAB, Cerdanyola del Vallès, Spain
- Valérie Schini-Kerth Faculty of Pharmacy, University of Strasbourg, Illkirch, France
- R.A. Shalliker Australian Centre for Research on Separation Science (ACROSS), School of Science and Health, University of Western Sydney (Parramatta), Sydney, NSW, Australia
- José Manuel Silván Department of Nutrition and Metabolism, Institute of Food Science and Technology and Nutrition (ICTAN-CSIC), Madrid, Spain
- Samo Smrke National Institute of Chemistry, Laboratory for Food Chemistry, Ljubljana, Slovenia

- Kevser Sözgen Başkan Istanbul University, Faculty of Engineering, Department of Chemistry, Avcilar, Istanbul, Turkey
- Ángela Suárez Jacobo CIATEJ, Unidad Noreste, Apodaca, Nuevo León, México
- **R. Subramanian** Academy of Scientific and Innovative Research, and Food Engineering Department, CSIR-Central Food Technological Research Institute, Mysore, India
- Jessica Tabart Plant Molecular Biology and Biotechnology B22, University of Liège, Plant Biology Institute, Sart Tilman, Liège, Belgium
- Andreia Tache National Institute for Biological Sciences, Bucharest, Romania
- Wessel du Toit Department of Viticulture and Oenology, Stellenbosch University, South Africa
- Esma Tütem Istanbul University, Faculty of Engineering, Department of Chemistry, Avcilar, Istanbul, Turkey
- Ioana Vasilescu National Institute for Biological Sciences, Bucharest, Romania

- **Aleksandra Vojvodić** Department of Food Engineering, Faculty of Food Technology and Biotechnology, University of Zagreb, Zagreb, Croatia
- Tong Wu Shanghai Institute of Pharmaceutical Industry, State Key Laboratory of New Drug & Pharmaceutical Process, Shanghai, China
- Dong-Ping Xu Guangdong Provincial Key Laboratory of Food, Nutrition and Health, Department of Nutrition, School of Public Health, Sun Yat-Sen University, Guangzhou, China
- Xiang-Rong Xu Key Laboratory of Marine Bio-resources Sustainable Utilization, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
- Chahan Yeretzian Zurich University of Applied Sciences, Institute of Chemistry and Biological Chemistry, Wädenswil, Switzerland
- Haifeng Zhao College of Light Industry and Food Sciences, South China University of Technology, Guangzhou, China

### Preface

Damage by oxidative stress is an important pathogenic step in the initiation of disease. Targets of oxidative stress and different free radical species include components of the cell, such as proteins, carbohydrate, lipids, nucleic acids and conjugated molecules. Organelles, pathways and metabolic processes are also affected. It is also becoming increasingly clear that some food components may be protective in those diseases caused by oxidative stress. For example, some epidemiological studies show that the lower prevalence of some cancers is associated with higher intake of foods that are rich in antioxidants. This is also supported by in vitro studies as well. On the other hand, excessive intake of some dietary antioxidants may be damaging. This suggests it is important to maintain a healthy balance between dietary levels of antioxidants and prooxidants. In the food industry antioxidants are added to preserve the shelf life of foods and prevent off-flavors developing. For example, vitamin E is used to prevent lipid peroxidation occurring. These production-added components also contribute to the overall intake of essential nutrients. Moreover, some production processes reduce the amount of naturally occurring antioxidants. Thus, there is an important need to understand not only the physiological importance of antioxidants, but their amount in the different food types, how they are reduced or enhanced by processing, what new antioxidants are being characterized and how they are measured. This is addressed in Processing and Impact on Antioxidants in Beverages. We cover wine, beer, coffee, tea, herbal infusions and other tea types, soft drinks, flavored waters and a wide variety of fruit juices.

The book is divided into three sections:

- [1] Composition and Characterization of Antioxidants
- [2] Effects of Production and Processing
- [3] Selective Assays for Antioxidants

In Section [1] Composition and Characterization of Antioxidants we have wine, beer, coffee, tea, herbal infusions and soft drinks. In Section [2] Effects of Production and Processing we cover fermentation, aging, varieties and growing conditions, preparation techniques, enzymes, storage, environmental factors, plant composition, homogenization and debittering. As well as the beverages mention in the previous Section we also cover rooibos and mate tea, goji, acai, pomegranate, grapefruit and juices in general. In Section [3] Selective Assays for Antioxidants we describe assays in a variety of beverages. Methods include the cuprac methods, the Oxygen Radical Absorbance Capacity (ORAC) and Trolox Equivalent Antioxidant Capacity (TEAC) assays, Off-line and Online HPLC assays, and methods for the derivation of a global antioxidant score.

Processing and Impact on Antioxidants in Beverages is designed for food scientists, technologist, food industry workers, as well as research scientists. Contributions are from leading national and international experts including those from world renowned institutions.

Professor Victor R. Preedy, King's College London

# Biography

Victor R. Preedy BSc, PhD, DSc, FSB, FRSH, FRIPH, FRSPH, FRCPath, FRSC is a senior member of King's College London (Professor of Nutritional Biochemistry) and King's College Hospital (Professor of Clinical Biochemistry: Hon). He is attached to both the Diabetes and Nutritional Sciences Division and the Department of Nutrition and Dietetics. He is also Director of the Genomics Centre and a member of the School of Medicine. Professor Preedy graduated in 1974 with an Honours Degree in Biology and Physiology with Pharmacology. He gained his University of London PhD in 1981. In 1992, he received his Membership of the Royal College of Pathologists and in 1993 he gained his second doctoral degree, for his outstanding contribution to protein metabolism in health and disease. Professor Preedy

was elected as a Fellow to the Institute of Biology in 1995 and to the Royal College of Pathologists in 2000. Since then he has been elected as a Fellow to the Royal Society for the Promotion of Health (2004) and The Royal Institute of Public Health (2004). In 2009, Professor Preedy became a Fellow of the Royal Society for Public Health and in 2012 a Fellow of the Royal Society of Chemistry. In his career Professor Preedy has carried out research at Imperial College London (National Heart Hospital) and the MRC Centre at Northwick Park Hospital. He is a leading expert on the science of health. He has lectured nationally and internationally. To his credit, Professor Preedy has published over 570 articles, which includes 165 peer-reviewed manuscripts based on original research, 100 reviews and over 50 books and volumes.

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# Biography

Victor R. Preedy BSc, PhD, DSc, FSB, FRSH, FRIPH, FRSPH, FRCPath, FRSC is a senior member of King's College London (Professor of Nutritional Biochemistry) and King's College Hospital (Professor of Clinical Biochemistry: Hon). He is attached to both the Diabetes and Nutritional Sciences Division and the Department of Nutrition and Dietetics. He is also Director of the Genomics Centre and a member of the School of Medicine. Professor Preedy graduated in 1974 with an Honours Degree in Biology and Physiology with Pharmacology. He gained his University of London PhD in 1981. In 1992, he received his Membership of the Royal College of Pathologists and in 1993 he gained his second doctoral degree, for his outstanding contribution to protein metabolism in health and disease. Professor Preedy

was elected as a Fellow to the Institute of Biology in 1995 and to the Royal College of Pathologists in 2000. Since then he has been elected as a Fellow to the Royal Society for the Promotion of Health (2004) and The Royal Institute of Public Health (2004). In 2009, Professor Preedy became a Fellow of the Royal Society for Public Health and in 2012 a Fellow of the Royal Society of Chemistry. In his career Professor Preedy has carried out research at Imperial College London (National Heart Hospital) and the MRC Centre at Northwick Park Hospital. He is a leading expert on the science of health. He has lectured nationally and internationally. To his credit, Professor Preedy has published over 570 articles, which includes 165 peer-reviewed manuscripts based on original research, 100 reviews and over 50 books and volumes.

# Composition and Characterization of Antioxidants

# 1

# Anthocyanic Compounds and Antioxidant Capacity in Fortified Wines

Isabel M.P.L.V.O. Ferreira\*, M. Trinidad Pérez-Palacios†

\*REQUIMTE, Laboratório de Bromatologia e Hidrologia, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Porto, Portugal, <sup>†</sup>Tecnología de los Alimentos, Facultad de Veterinaria, Universidad de Extremadura, Cáceres, Spain

#### CHAPTER POINTS

- · Definition of fortified wines.
- Classification of Port, Sherry, Madeira, Moscatel, Marsala wines.
- · Polyphenolic content of fortified wines.
- Anthocyanins in fortified wines and factors affecting degradation of these pigments.
- · Antioxidant capacity of fortified wines.
- Aging process is a major factor influencing the antioxidant activity of fortified wines.

#### INTRODUCTION

Fortified wines contain additional alcohol that has been added to the base wine during fermentation, when part of the original sugar content has been converted to alcohol. Thus in these wines, must fermentation is stopped by the addition of a neutral grape spirit, reaching a final alcohol content around 17–22%. Many fortified wines are blends of various grapes and various vintages. Fortified wines are known for their long-standing contribution to the world of wine as both an aperitif and a dessert wine option (Jackson, 2008).

Fortified wines can be made in either dry or sweet styles (with the middle-ground of medium-sweet or medium-dry covered in virtually all types of fortified wine categories). The determining factor of the sweetness/dryness of fortified wine is the point at which the addition of alcohol occurs during fermentation (Jackson, 2008). A sweeter fortified wine is obtained by adding

the alcohol within the first day and a half of fermentation; thus, the yeast stops converting sugar to alcohol and all of the remaining grape sugar is left in the wine as residual sugar. Conversely, to obtain a dry fortified wine, the full fermentation process must occur, consuming the remaining sugar and then the alcohol is added to the wine. Table 1.1 summarizes classification of the most common types of fortified wines (Port, Sherry, Madeira, Moscatel, and Marsala) according to their sugar content.

Biochemical reactions catalyzed by enzymes of yeasts and bacteria and chemical reactions between molecules present in the must, which were extracted from the grape solids during fermentation, derived from metabolism, or released by the wood, start as soon as the beginning of winemaking (crushing) and continue through fermentation and aging (Perestrelo et al., 2011). Aging is an important feature for fortified wines and includes bulk storage maturation in barrels or tanks and in-bottle aging (Pinho et al., 2012). The aging time depends on the fortified wine, but in general the cheaper the fortified wine, the less time it has spent aging in oak. As a result of deep wood aging, many fortified wines will benefit from decanting and aeration. Apart from location, grape varieties, soil, etc., there are also differences in the way the most common types of fortified wines (Port, Sherry, Madeira, Moscatel, and Marsala) are fortified and aged (Table 1.2).

### Port Wine

Port wine is produced primarily from red grapes grown and fermented in the upper Douro Valley in northern Portugal. Although originating in the upper Douro, the wine is transported downriver to Porto for maturation and aging. These processes occur in buildings called lodges in Vila Nova de Gaia, located at the mouth of the Douro River, opposite the city of Porto. The major red varieties are Touriga Nacional, Mourisco, Mourisco de Semente, Tinta Roriza, Tinta Cão, and Tinta Francisco, Tinta Barroca (Mateus et al., 2002). A small amount of white Port is also produced. Codega, Malvasia, and Rabigato are the preferred white varieties. Most of the present-day wine is vinified by regional cooperatives using modern crushing, pressing, and fermenting equipment. When part of the original sugar content has been converted to alcohol, must fermentation is stopped by the addition of wine spirit obtaining around 20% of the final alcohol content (Esteves et al., 2004). Aging includes bulk storage maturation in barrels or tanks and in-bottle aging.

Different types of Port wines are produced. Ruby Port wine is the most extensively produced type. After fermentation, it is stored (in general, for 2 years) in tanks made of stainless steel to prevent oxidative aging and to preserve its rich claret color. It is fined and cold

**TABLE 1.1** Classification of Fortified Wines According to their Sugar Content

Wine	Category	Residual Sugar (g/l)
Port	Very sweet	>130
Sherry	Sweet	90–130
	Semi-dry	65–90
	Dry	45-65
	Extra-dry	< 40
	Dulce/Sweet	>160
	Pedro Ximénez	>212
	Cream	115–140
	Medium	5–115
	Pale Cream	45–115
Madeira	Dry	5–45
	Fino/ Manzanilla/Oloroso/ Palo Cortado/Amontillado	0–5
	Sweet (Malvasia)	110
	Medium dry (Verdelho)	90
	Medium sweet (Boal)	65
	Dry (Sercial)	25
Moscatel de Setúbal		90–100
Marsala	Dolce	> 100
	Semi-secco	40-100
	Secco	<40

filtered before bottling and does not generally improve with age. Ruby Port wine is usually blended to match the style of the brand to which it is to be sold. Tawny Ports are wines made from red grapes that are aged in wooden barrels and blended in such a way that the finished product is a mixture of ages. A Tawny without an indication of age (usually named as Reserve) has spent at least 2 years in wooden barrels, exposing it to gradual oxidation and evaporation until a golden-color is obtained, and it is blended in such a way that the finished product is a mixture of ages. Tawny wines with age categories (10, 20, 30, and over 40 years) indicate a target age profile. Vintage Port is made entirely from the grapes of a declared vintage year, aged in barrels for a maximum of 21/2 years, and bottled unfined. Generally, it requires another 10 to 40 years of aging in the bottle. Late Bottle Vintage (LBV) is the product of a single year's harvest that was left in the barrel for 4-6 years. LBV can be fined and filtered or not before being bottled (Pinho et al., 2012). White Port is made from white grapes and can be made in a wide variety of styles, from dry to very sweet (Jackson, 2008).

### Sherry Wine

Sherry is a fortified wine made from white grapes that are grown near the town of Jerez de la Frontera in Andalusia, Spain. Sherry is produced in a variety of dry styles made primarily from the Palomino grape. After fermentation is complete, the base wines are fortified with grape spirit in order to increase their final alcohol content. Wines classified as Fino and Amontillado are fortified until they reach a total alcohol content of 15-17%. Those wines classified as Oloroso are fortified to reach an alcohol content of at least 17-22% (BOJA, 2012; Stevenson, 2005). Sherry wines are aged and blended using the solera system: a series of 3-9 barrels are used, and the method involves moving the wine down from one barrel into the next one. At the end of the series only a portion of the final barrel is bottled and sold. Depending on the type of wine, the portion moved may be between 5 and 30% of each barrel. The amount added is equivalent to that removed for transfer to older wine or bottling. The age of the youngest wine going into the bottle is determined by the number of barrels in the series, and every bottle also contains some much older wine. Sherry is aged in the solera for a minimum of 3 years. Fino Sherries require many and frequent transfers and stages whereas Oloroso Sherries develop best with few and infrequent transfers. Amontillado Sherries begin similarly to Fino Sherry, but subsequently, the frequency of transfer is slowed. Sweet Sherries (Pedro Ximénez) are made either by fermenting sweet grape varieties (Pedro Ximénez or Moscatel) or by blending sweeter wines (Jackson, 2008).