

PREFACE

Anthocyanins and flavonoids with their diverse colors have been distributed abundantly in especially higher plants of plant kingdom as natural pigments. Daily diets such as vegetables and fruits have also these pigments, which have the different functions for human health. The purpose of this book is to describe their distributions, extractions, separations, characterization, stability, functions, biosynthesis pathway, the regulation of the biosynthetic enzymes by anthocyanins and flavonoids, food colors, and molecular biology such as a relationship of biomolecule with anthocyanins or flavonoids in vegetables and fruits.

Chapter 1 - Pulp of kiwifruits have attractive green red or yellow colors. These natural pigments contain their many diverse anthocyanins and their aglycones such as delphinidin and cyanidin. Kiwifruit anthocyanins and flavonoids could represent to be beneficent as human daily safe and functional foods with their improvement of oxidative stressed brain, complex formation of flavonoid-metal-ascorbic acid, preventive resistance for endogenous oxidative damage, antioxidative activity, anti-hepatofibrotic activity and others. Based on these facts, this chapter describes mainly the kiwifruit flavonoids and anthocyanins, and their antioxidative health effects of the evidence-based kiwifruit flavonoids.

Chapter 2 - Muscadine berries (*Vitis rotundifolia* Michx.) are hardy grapes indigenous to the South Eastern United States of America with high antioxidant and anti-inflammatory properties. Noble fresh red muscadine berries were crushed, and the juice was separated. The crushed grapes contain different polyphenols such as proanthocyanidins, gallic acid, ellagic acid, resveratrol, and anthocyanins. The anthocyanins which give the color to the muscadine berries are antioxidants useful for cardio-protection, cholesterol-lowering and vision-improvement. Additionally, anthocyanins could suppress the DNA-damaging effects of topoisomerase poisons in human colon cancer cells. This chapter suggests muscadine berries might have important benefits in age-related diseases such as cardio-protection, cholesterol-lowering, vision-improvement, and possibly certain types of cancer.

Chapter 3 - Polyphenols are naturally occurring aromatic hydroxylated compounds which could be divided into different subclasses viz., phenylethanol derivatives, phenolic acids, flavones and flavonols, catechins, procyanidins and anthocyanins. Anthocyanins are glycosylated polyhydroxy and polymethoxy derivatives of flavylum salts responsible for the brilliant red, orange and blue colors of most fruits and flowers and have shown antioxidative, antimutagenic, antidiabetic and anticarcinogenic activities *in vitro*.

Electrochemical techniques viz., cyclic voltammetry, square wave voltammetry, differential pulse voltammetry and amperometry have been employed for the characterization

of the antioxidant and electrochemical properties of anthocyanins from their diverse sources and for their assay in fruit juices and plant extracts. Further, the assay of anthocyanins and related compounds from various natural sources by analytical methods *viz.*, spectrophotometry, spectrofluorimetry, voltammetry, HPLC, LC-MS, MS/MS, MALDI-TOF-MS and others has been incorporated. The chapter also reports the interactions of anthocyanins and related compounds with macromolecules by spectroscopic methods *viz.*, UV-absorption, fluorescence, FTIR, circular dichroism and 3-D fluorescence, and voltammetric techniques.

Chapter 4 – Rice anthocyanins are a kind of reddish-purple water-soluble flavonoids that are present in the red and black pigmented rice (*Oryza sativa* L.) grains or plants. Rice anthocyanins could show potent antioxidative effects against reactive oxygen radicals generated in the human body. By now, many studies indicate that consumption of black rice has a number of beneficial properties such as antioxidant, α -glucosidase inhibitory, hepatoprotective, antidiabetic, anti-inflammatory and anti-carcinogenic effects. Their biosynthetic pathway of anthocyanins in rices could provide a possible strategy to improve anthocyanins and other flavonoid contents in rice grains by the genetic engineering techniques. Black rice accumulating anthocyanins in the endosperm are strongly expected. This chapter summarizes the knowledge on the genetics, biosynthesis and health benefits of anthocyanins in rice grains. This chapter gives a suggestion for the production of further novel rice products with more anthocyanin.

Chapter 5 - Sickle cell disease is a genetic, hereditary, autosomale and recessive disease, where there is a replacement of the glutamic acid located in sixth position on the beta chain of normal haemoglobin by valin. This replacement of a polar amino acid by a less polar amino acid causes a polymerization of the haemoglobin S in the red globules. In Sub-Saharan Africa, the mainly affected area by this genetic disease, medicinal plants are intensely used to manage sickle anaemia. Some Congolese plants have shown *in vitro* and *in vivo* antisickling activities. These biological activities seem mainly to be due to anthocyanin extracts. Anthocyanin extracts of some species of *Justicia* such as *Justicia matammensis* and *Justicia laxa* displayed interesting antisickling activity *in vitro*.

Chapter 6 – Anthocyanins are susceptible to the heat and light which cause color deterioration in manufacturing process, transportation, and preservation of foods such as strawberry jam. In this study, the effects of temperature and the relative humidity during the preservation on the stability of anthocyanin in strawberry jam were evaluated. Their degradation was suppressed by the formation of the inclusion complex of anthocyanins with cyclodextrin due to its cyclic molecular structure or lowering the water activity in the jam. The impregnation of strawberry with sucrose in advance of the jam preparation stabilized anthocyanins in the jam. Moreover, the relationship between the two rate constants was almost linear. This chapter showed to prevent the oxidation or degradation of food anthocyanins in strawberry by using cyclodextrin and sucrose with the effective improvement of the stabilities of both anthocyanins and the colors in the jam.

Chapter 7 – The consumers are interested in healthier colorful products such as anthocyanins. Although these natural pigments are widely spread in nature, their extraction procedure demands special attention to avoid degradation. Due to this difficulty, the extraction method plays a fundamental role in the recovery of anthocyanins from natural sources. This chapter presents the recent work of our research group (LASEFI/DEA/FEA/UNICAMP) for obtaining anthocyanins from skins of a Brazilian fruit

named jaboticaba (*Myrciaria cauliflora*). Several results from conventional and innovative extraction technologies are summarized and discussed with the aim of comparing extraction performances in terms of anthocyanins recovery. This chapter gives a more complete understanding on the influence of different extraction methods on the recovery of anthocyanins.

Chapter 8 – Over 600 anthocyanins have been identified by now. These structures have been determined by high-performance liquid chromatography (HPLC) coupled to UV-Vis (UV) detector and diode array detector (DAD) and different mass spectrometry (MS) analyzer, such as ion trap (IT), quadrupole (Q), time-of-flight (TOF) and hybrid analyzers Q-TOF. MS has been generally coupled to different ion sources such as electrospray ionization (ESI) and matrix-assisted laser desorption/ionization (MALDI). Moreover, capillary electrophoresis (CE) coupled to DAD and MS detectors has also been used to characterize anthocyanins. Among these analytical methods, the UV-Vis spectra represents a valuable analytical tool for the identification of anthocyanins because they have an specific and intense absorbance band in the range of 520 to 560 nm; meanwhile, MS is a powerful tool which can provide information on molecular mass and also structural features of the different constituents. This chapter is to overview the uses of HPLC and CE coupled to different detection systems discussing the fundamentals of sample extraction and separation.

Chapter 9 – Since long ago, jujubes including berry fruits, seeds and leaves have been traditionally used in preventions and treatments for stress, antifungal, antibacterial, antiulcer, anti-inflammatory, sedative, antispastic, antifertility or contraception, hypotensive and antinephritic, cardiotonic, antioxidant, immunostimulant, wound healing properties and others in China, India, Korea and their surrounding countires. The jujube contains their phytochemicals with their highly beneficent functionality for humans such as sugars, dietary fiber, alkaloids, terpenoids, and flavonoids and anthocyanins. This chapter describes mainly the diverse anthocyanins and flavonoids, and their functions based on their evidences by the health effects of jujubes.

Chapter 10 – Anthocyanins are found in many fruits such as berries, grapes, cherries, pomegranates, plums, apples and some citrus. They have high antioxidant potency, and could act as antimicrobials agents and UV radiation absorbers. Anthocyanins structurally belong to the flavonoids, and are glycosydes containing a sugar moiety and an aglycone unit (the anthocyanidin). More than 635 different anthocyanins and 23 anthocyanidins have been reported. The distribution frequency of the six most common anthocyanidins in fruits ranges from 5 % (petunidin) up to 30 % (cyanidin). The conformation of anthocyanins has great impact in their color, stability, co-pigmentation capacity and antioxidant properties. This chapter describes the distribution of anthocyanins in fruits, and analyzes the effect of pre- and postharvest conditions and/or treatments on their accumulation and fate.

Chapter 11 – Resveratrol mainly in grape skin has been recognized for its cardiovascular protective effects. Based on “French paradox” the observation that the French suffer a relatively low incidence of coronary heart disease, despite having a diet relatively rich in saturated fats, might be directly related to the antioxidative activity of wine. Moreover, its physiological effects are widening based on many studies related to anti-cancer, anti-obesity and neuroprotective properties. Therefore, this chapter suggests that resveratrol might play a leading role as a substance for new drug development and in increasing economic value due to the increase in wine consumption worldwide.

Chapter 12 – Anthocyanins are a member of the bioflavonoid phytochemicals. Anthocyanins have their health-promoting functions for recent years. Among many berry fruits, bilberries have been particularly known as one of the richest sources of anthocyanins since long ago. The physiological effects of anthocyanins in humans might depend on the absorption after ingestion. The clinical studies on the bioavailability of anthocyanins were very low and highly variable because of their instability in physiological absorption conditions. Then, the targets for the development of improved anthocyanin products might elevate more absorption and reduced the absorption variability. A copigmentation of anthocyanins might be a natural occurring mechanism to stabilize anthocyanins. Based on these ideas, the anthocyanin extracts of bilberry fruits have been investigated for their copigmentation effects in solution. Bilberry Anthocyanin Extracts (BAEs) with the strong copigmentation effects were tested by both, an *in vitro* CaCo-2 cell culture system and an *in vivo* human clinical trial. This chapter describes the copigmentation effects of BAEs might increase an increased absorption by the reduced absorption variability.

Chapter 13 – Some selected red wines from Morocco were studied on their antioxidant activities. These wines had high anthocyanin contents with antioxidant capacity for reactive oxygen species. There is a good relationship of their antioxidant capacity with two DPPH and FRAR assays on the wines. From these results, this chapter suggests that the intake of these wines in daily foods might be beneficial for human health.

Chapter 14 – Taros have been primarily used in their diverse culinary regions as major cereal crops in tropical and subtropical areas also including temperate region such as Japan and Korea. In these areas, taros also have been used as traditional medicines in preventions and treatments for hypertension, constipation, diuretic and other age-related diseases. By now, human has ingested their dietary anthocyanins with different colors in fruit, corm and vegetable to unknowingly. These having functionality could play a beneficial role in retarding or reversing the course of chronic degenerative diseases such as hypertension, diabetes and cardiac failure. This chapter represents their diverse functions of mainly taro anthocyanins to human health by taro as a vegetable or corm.

January 17, 2012

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