

Chapter

4

THE ROLE OF STRAWBERRY SECONDER COMPOUNDS ON HEALTH

Mehmet Ali SARIDAŞ¹
Furkan Cihad AKBAŞ²
Sevgi PAYDAŞ KARGI³

ABSTRACT

It is known that the average lifetime of people in the world and our country has increased significantly with the developing technology in medical science. However, some important aging diseases started to occur. As a result of the studies conducted in recent years, it has been determined that the risk of these diseases decreased as fruits and vegetables which contain secondary compounds such as flavonoids has been consumed. In this chapter, the properties of the mentioned compounds on the basis of strawberries, their effects on diseases, the availability and the procedures for increasing these compounds in the product are examined in detail and the conducted studies are summarized. As a result of the evaluations, it was found that, despite its nominal bioavailability, strawberry could be an important resource with its high anthocyanin content, which has proved its positive effects on health. In addition, it is remarkable that compounds such as ellagic and gallic acid are important due to their high bioavailability, although they are relatively low in quantity. It is known that the ratio of cardiovascular diseases, diabetes, and cancer is increasing day by day due to the cases such as prolonging of lifetime, different living conditions and irregular eating habits. In this context, it has been clearly determined that fruits containing high levels of secondary

¹ Dr. Mehmet Ali SARIDAŞ, Çukurova Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümü, Balcalı Adana 01330, Türkiye, masaridas@gmail.com

² Furkan Cihad AKBAŞ, Çukurova Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümü, Balcalı Adana 01330, Türkiye, furkancakbas@gmail.com

³ Prof. Dr. Sevgi PAYDAŞ KARGI, Çukurova Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümü, Balcalı Adana 01330, Türkiye, sevpay@cu.edu.tr

REFERENCES

1. Adak, N., Gübbük, H. & Tetik, N. (2018) Yield, quality and biochemical properties of various strawberry cultivars under water stress. *Journal of the Science of Food and Agriculture*, 98 (1), 304-331.
2. Adeva-Andany, M.M., Martínez-Rodríguez, J., González-Lucán, M., Fernández-Fernández, C. & Castro-Quintela, E. (2019) Insulin resistance is a cardiovascular risk factor in humans. *Diabetes & Metabolic Syndrome*, 13 (2), 1449-1455. Doi: 10.1016/j.dsx.2019.02.023.
3. Afrin, S., Gasparrini, M., Forbes-Hernandez, T.Y., Reboredo-Rodríguez, P., Mezzetti, B., Varela-Lopez, A., Giampieri, F. & Battino, M. (2016) Promising health benefits of the strawberry: a focus on clinical studies. *Journal of Agricultural and Food Chemistry*, 64 (22), 4435-4449.
4. Amani, R., Moazen, S., Shahbazian, H., Ahmadi, K. & Jalali, M.T. (2014) Flavonoid-rich beverage effects on lipid profile and blood pressure in diabetic patients. *World Journal of Diabetes*, 5, 962.
5. American Diabetes Association (2019). 5. Lifestyle management: standards of medical care in diabetes. *Diabetes Care*, 42 (Supplement 1), S46-S60. Doi: 10.2337/dc19-S005
6. Amiot, M.J. & Riva, C.A.V. (2016) Effects of dietary polyphenols on metabolic syndrome features in humans: A systematic review. *Obesity Reviews*, 17, 573-586.
7. Azzini, E., Vitaglione, P., Intorre, F., Napolitano, A., Durazzo, A., Foddai, M.S., Fumagalli, A., Catasta, G., Rossi, L. & Venneria, E. (2010) Bioavailability of strawberry antioxidants in human subjects. *British journal of nutrition*, 104, 1165-1173.
8. Babu, P.V., Liu, D. & Gilbert, E.R. (2013) Recent advances in understanding the anti-diabetic actions of dietary flavonoids. *Journal of Nutritional Biochemistry*, 24 (11), 1777-1789. Doi: 10.1016/j.jnutbio.2013.06.003.
9. Basu, A., Fu, D.X., Wilkinson, M., Simmons, B., Wu, M., Betts, N.M., Du, M. & Lyons, T.J. (2010b) Strawberries decrease atherosclerotic markers in subjects with metabolic syndrome. *Nutrition research*, 30, 462-469.
10. Basu, A., Rhone, M. & Lyons, T.J. (2010a) Berries: emerging impact on cardiovascular health. *Nutrition Reviews*, 68 (3), 168-177.
11. Battino, M., Forbes-Hernández, Y.T., Gasparrini, M., Afrin, S., Cianciosi, D., Zhang, J., Manna, P.P., Reboredo-Rodríguez, P., Lopez, A.V., Quiles, J.L., Mezzetti, B., Bompadre, S., Xiao, J. & Giampieri, F. (2019) Relevance of functional foods in the Mediterranean diet: the role of olive oil, berries and honey in the prevention of cancer and cardiovascular diseases. *Critical Reviews in Food Science and Nutrition*, 59 (6), 893-920. Doi:10.1080/10408398.2018.1526165.
12. Beer, C., Myers, R.A., Sorenson, J.H. & Bucci, L.R. (2004) Comprehensive comparison of the antioxidant activity of fruits and vegetables based on typical serving sizes from common methods. *Current Topics in Nutraceutical Research*, 2, 227-250.
13. Bhagwat, S., Haytowitz, D.B. & Holden, J.M. (2014) USDA database for the flavonoid content of selected foods, Release 3.1. *US Department of Agriculture: Beltsville, MD, USA*.
14. Bishayee, A., Haskell, Y., Do, C., Siveen, K.S., Mohandas, N., Sethi, G. & Stoner, G.D. (2015) Potential Benefits of Edible Berries in the Management of Aerodigestive and Gastrointestinal Tract Cancers: Preclinical and Clinical Evidence. *Critical Reviews in Food Science & Nutrition*, 56 (10), 1753. Doi: 10.1080/10408398.2014.982243.
15. Bonita, J.S., Mandarano, M., Shuta, D. & Vinson, J. (2007) Coffee and cardiovascular disease: in vitro, cellular, animal, and human studies. *Pharmacological research*, 55 (3), 187-198. Doi: 10.1016/j.phrs.2007.01.006
16. Bushman, B.S., Phillips, B., Isbell, T., Ou, B., Crane, J.M. & Knapp, S.J. (2004) Chemical composition of caneberry (*Rubus* spp) seeds and oils and their antioxidant potential. *Journal of Agricultural and Food Chemistry*, 52, 7982-7987.
17. Cartron, E., Fouret, G., Carbonneau, M.A., Lauret, C., Michel, F., Monnier, L., Descomps, B. & Leger, C.L. (2003) Red-wine beneficial long-term effect on lipids but not on antioxidant characteristics in plasma in a study comparing three types of wine-description of two O-meth-

- ylated derivatives for gallic acid in humans. *Free Radical Research*, 37, 1021-1035.
18. Cassidy, A., Mukamal, K.J., Liu, L., Franz, M., Eliassen, A. H. & Rimm, E. B. (2013) High anthocyanin intake is associated with a reduced risk of myocardial infarction in young and middle-aged women. *Circulation*, 127, 188–196.
 19. Chen, W., Xu, Y., Zhang, L., Li, Y. & Zheng, X. (2016) Wild raspberry subjected to simulated gastrointestinal digestion improves the protective capacity against ethyl carbamate-induced oxidative damage in Caco-2 cells. *Oxidative Medicine and Cellular Longevity*, 2016. Doi: 10.1155/2016/3297363.
 20. Chidambaram, M., Manavalan, R. & Kathiresan, K. (2011) Nanotherapeutics to overcome conventional cancer chemotherapy limitations. *Journal of pharmacy & pharmaceutical sciences*, 14 (1), 67-77. Doi: 10.18433/J30C7D.
 21. Crozier, A., Yokota, T., Jaganath, I. B., Marks, S. & Saltmarsh, M. (2006) Secondary metabolites as dietary components in plant-based foods and beverages. *Plant Secondary Metabolites and the Human Diet*, 208-302.
 22. Czank, C., Cassidy, A., Zhang, Q., Morrison, D.J., Preston, T., Kroon, P.A., Botting, N.P. & Kay, C.D. (2013) Human metabolism and elimination of the anthocyanin, cyanidin-3-glucoside: a 13C-tracer study. *The American of Clinical Nutrition*, 97 (5), 995-1003. Doi: 10.3945/ajcn.112.049247.
 23. D'Archivio, M., Filesi, C., Vari, R., Scaccocchio, B. & Masella, R. (2010) Bioavailability of the polyphenols: Status and controversies. *International journal of molecular sciences*, 11 (4), 1321-1342.
 24. Edirisinghe, I., Banaszewski, K., Cappozzo, J., Sandhya, K., Ellis, C.L., Tadapaneni, R., Kapagoda, C.T. & Burton-Freeman, B.M. (2011) Strawberry anthocyanin and its association with postprandial inflammation and insulin. *British Journal of Nutrition*, 106 (6), 913-922.
 25. Ely, E.K., Gruss, S.M., Luman, E.T., Gregg, E.W., Ali, M.K., Nhim, K., Rolka, D.B. & Albright, A.L. (2017) A national effort to prevent type 2 diabetes: participant-level evaluation of CDC's National Diabetes Prevention Program. *Diabetes care*, 40 (10), 1331-1341. Doi: 10.2337/dc16-2099.
 26. Erlund, I., Koli, R., Alftan, G., Marniemi, J., Puukka, P., Mustonen, P., Mattila, P. & Jula, A. (2008) Favorable effects of berry consumption on platelet function, blood pressure, and HDL cholesterol. *The American Journal of Clinical Nutrition*, 87 (2), 323-331.
 27. Ferlay, J., Soerjomataram, I., Dikshit, R., Eser, S., Mathers, C., Rebelo, M., Parkin Maxwell, D., Forman, D. & Bray, F. (2015) Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. *International journal of cancer*, 136 (5), E359-E386. Doi: 10.1002/ijc.29210
 28. Fernandes, I., Marques, F., De, F.V. & Mateus, N. (2013) Antioxidant and antiproliferative properties of methylated metabolites of anthocyanins. *Food Chemistry*, 141 (3), 2923-2933. Doi: 10.1016/j. foodchem.2013.05.033.
 29. Fitzpatrick, F.A. (2004) Cyclooxygenase enzymes: regulation and function. *Current Pharmaceutical Design*, 10 (6), 577-588.
 30. Forbes-Hernandez, T.Y., Giampieri, F., Gasparri, M., Afrin, S., Mazzoni, L., Cordero, M.D., Mezzetti, B., Quiles, J.L. & Battino, M. (2017) Lipid accumulation in HepG2 cells is attenuated by strawberry extract through AMPK activation. *Nutrients*, 9 (6), 621.
 31. Giampieri, F., Alvarez-Suarez, M., Mazzoni, L., Romandini, S., Bompadre, S., Diamanti, J., Capocasa, F., Mezzetti, B., Quiles, J. L., Ferreiro, M. S., Tulipani, S. & Battino, M. (2013) The potential impact of strawberry on human health. *Natural Product Research*, 27, 448-455.
 32. Hannum, S.M. (2004) Potential impact of strawberries on human health a review of the science. *Critical Reviews in Food Science and Nutrition*, 44 (1), 1-17.
 33. He, K., Li, X., Chen, X., Ye, X., Huang, J., Jin, Y., Li, P., Deng, Y., Jin, Q., Shi, Q. & Shu, H. (2011) Evaluation of antidiabetic potential of selected traditional Chinese medicines in STZ-induced diabetic mice. *Journal of Ethnopharmacology*, 137 (3), 1135-1142. Doi: 10.1016/j. jep.2011.07.033.

34. Huang, H.P., Chang, Y.C., Wu, C.H., Hung, C.N. & Wang, C.J. (2011) Anthocyanin-rich Mulberry extract inhibit the gastric cancer cell growth in vitro and xenograft mice by inducing signals of p38/ p53 and c-jun. *Food Chemistry*, 129 (4), 1703-1709. Doi: 10.1016/j. foodchem.2011.06.035.
35. Hui, C., Xie, Y. & Chen, X. (2015). Type 2 diabetes diminishes the benefits of dietary antioxidants: Evidence from the different free radical scavenging potential. *Food Chemistry*, 186, 106-112. Doi: 10.1016/j. foodchem.2014.06.027.
36. Hussain, T., Tan, B., Yin, Y., Blachier, F., Tossou, M.C. & Rahu, N. (2016) Oxidative Stress and Inflammation: What Polyphenols Can Do for Us? *Oxidative medicine and cellular longevity*, 2016.
37. Jennings, A., Welch, A. A., Fairweather-Tait, S. J., Kay, C., Minihane, A. M., Chowienczyk, P., Jiang, B., Cecelja, M., Spector, T., Macgregor, A. & Cassidy, A (2012) Higher anthocyanin intake is associated with lower arterial stiffness and central blood pressure in women. *The American Journal of Clinical Nutrition*, 96 (4), 781-788.
38. Jennings, A., Welch, A.A., Spector, T., Macgregor, A. & Cassidy, A. (2014). Intakes of anthocyanins and flavones are associated with biomarkers of insulin resistance and inflammation in women. *The Journal of Nutrition*, 144 (2), 202-208. Doi: 10.3945/ jn.113.184358.
39. Joseph, J.A., Shukitthale, B., Denisova, N.A., Bielinski, D., Martin, A., McEwen, J.J. & Bickford, P.C. (1999) Reversals of age-related declines in neuronal signal transduction, cognitive, and motor behavioral deficits with blueberry, spinach, or strawberry dietary supplementation. *Journal of Neuroscience*, 19 (18), 8114-8121.
40. Joseph, S. V., Edirisinghe, I. & Burton-Freeman, B.M. (2014) Berries: anti-inflammatory effects in humans. *Journal of Agricultural and Food Chemistry*, 62 (18), 3886-3903.
41. Kahkonen, M.P., & Heinonen, M. (2003) Antioxidant activity of anthocyanins and their aglycons. *Journal of Agricultural and Food Chemistry*, 51 (3), 628-633. Doi: 10.1021/jf025551i.
42. Kalt, W., Forney, C.F. & Martin, R.L. (1999) Prior Antioxidant capacity vitamin C phenolics and anthocyanins after storage of small fruits. *Journal of Agricultural and Food Chemistry*, 47, 4638-4644.
43. Kapur, B., Saridaş, M.A., Çeliktopuz, E., Kafkas, E., Paydaş Kargı, S. (2018) Health and taste related compounds in strawberries under various irrigation regimes and bio-stimulant application. *Food chemistry*, 263, 67-73.
44. Kaur, S. & Das, M. (2011) Functional foods: An overview. *Food Science and Biotechnology*, 20, 865-875.
45. Kausar, H., Jeyabalan, J., Aqil, F., Chabba, D., Sidana, J., Singh, I.P. & Gupta, R.C. (2012) Berry anthocyanidins synergistically suppress growth and invasive potential of human non-small-cell lung cancer cells. *Cancer Letters*, 325 (1), 54-62. Doi: 10.1016/j.canlet.2012.05.029.
46. Khoo, H.E., Azlan, A., Tang, S.T. & Lim, S.M. (2017) Anthocyanidins and anthocyanins: colored pigments as food, pharmaceutical ingredients, and the potential health benefits. *Food & Nutrition Research*, 61 (1), 1361779. Doi: 10.1080/16546628.2017.1361779.
47. Konishi, Y., Hitomi, Y. & Yoshioka, E. (2004) Intestinal absorption of p-coumaric and gallic acids in rats after oral administration. *Journal of Agricultural and Food Chemistry*, 52, 2527-2532.
48. Kroon, P.A., Clifford, M.N., Crozier, A., Day, A.J., Donovan, J.L., Manach, C. & Williamson, G. (2004) How should we assess the effects of exposure to dietary polyphenols in vitro? *The American journal of clinical nutrition*, 80 (1), 15-21.
49. Lafay, S. & Gil-Izquierdo, A. (2007) Bioavailability of phenolic compounds. *Phytochemistry Reviews* 7, 301-311.
50. Lei, F., Xing, D.M., Zhao, Y.N., Zhang, L.J. & Du, L.J. (2003) Pharmacokinetic study of ellagic acid after oral administration of pomegranate leaf extract. *Journal of Chromatography B*, 796 (1), 189-194.
51. Liao, F.H., Shieh, M. J., Chang, N.C. & Chien, Y.W. (2007) Chitosan supplementation lowers serum lipids and maintains normal calcium, magnesium, and iron status in hyperlipidemic patients. *Nutrition Research*, 27 (3), 146-51. Doi: 10.1016/j.nutres.2007.01.009.

52. Libby, P., Okamoto, Y., Rocha, V. Z. & Folco, E. (2010) Inflammation in atherosclerosis: transition from theory to practice. *Circulation Journal Official Journal of the Japanese Circulation Society*, 74 (2), 213-20. Doi: 10.1253/circj.CJ-09-0706.
53. Lopes da Silva, F., Escribano-Bailón, M.T., Alonso, J.J.P., Rivas-Gonzalo, J.C. & Santos-Buelga, C. (2007) Anthocyanin pigments in strawberry. *LWT*, 40, 374-382.
54. Matsumoto, H., Inaba, H., Kishi, M., Tominaga, S., Hirayama, M. & Tsuda, T. (2001) Orally administered delphinidin 3-rutinoside and cyanidin 3-rutinoside are directly absorbed in rats and humans and appear in the blood as the intact forms. *Journal of Agricultural and Food Chemistry*, 49 (3), 1546-1551.
55. McCullough, M.L., Peterson, J.J., Patel, R., Jacques, P.F., Shah, R. & Dwyer, J.T. (2012) Flavonoid intake and cardiovascular disease mortality in a prospective cohort of US adults. *The American Journal of Clinical Nutrition*, 95 (2), 454-464.
56. McGhie, T.K. & Walton, M.C. (2007) The bioavailability and absorption of anthocyanins: towards a better understanding. *Molecular Nutrition & Food Research*, 51 (6), 702-713.
57. Mink, P.J., Scrafford, C.G., Barraj, L. M., Harnack, L., Hong, C.P., Nettleton, J.A. & Jacobs Jr, D.R. (2007) Flavonoid intake and cardiovascular disease mortality: a prospective study in postmenopausal women. *The American journal of clinical nutrition*, 85 (3), 895-909.
58. Muraki, I., Imamura, F., Manson, J.E., Hu, F.B., Willett, W.C., van Dam, R.M., Sun, Q. (2013) Fruit consumption and risk of type 2 diabetes: results from three prospective longitudinal cohort studies. *BMJ*, 347, f5001.
59. Netzel, M., Strass, G., Kaul, C., Bitsch, I., Dietrich, H. & Bitsch, R. (2002) In vivo antioxidative capacity of a composite berry juice. *Food Research International*, 35 (2-3), 213-216.
60. Nielsen, I.L.F., Dragsted, L.O., Ravin-Haren, G., Freese, R. & Rasmussen, S.E. (2003) Absorption and excretion of black currant anthocyanins in humans and Watanabe heritable hyperlipidemic rabbits. *Journal of Agricultural and Food Chemistry*, 51 (9), 2813-2820.
61. Nile, S.H. & Park, S.W. (2014) Edible berries: Bioactive components and their effect on human health. *Nutrition*, 30, 134-144.
62. Noda, Y., Kneyuki, T., Igarashi, K., Mori, A. & Packer, L. (2005) Antioxidant activity of nasunin, an anthocyanin in eggplant peels. *Research Communications in Molecular Pathology & Pharmacology*, 53 (16), 6272-6275.
63. Nowicka, A., Kucharska, A.Z., Sokół-Łętowska, A. & Fecka, I., (2019) Comparison of polyphenol content and antioxidant capacity of strawberry fruit from 90 cultivars of *Fragaria x ananassa* Duch. *Food Chemistry*, 270: 32-46.
64. Paredeslópez, O., Cervantesceja, M.L., Vignapérez, M. & Hernándezpérez, T. (2010) Berries: improving human health and healthy aging, and promoting quality life-a review. *Plant Foods for Human Nutrition*, 65 (3), 299-308. Doi: 10.1007/s11130-010-0177-1.
65. Parry, J., Su, L., Luther, M., Zhou, K., Yurawecz, M. P., Whittaker, P. & Yu, L. (2005) Fatty acid composition and antioxidant properties of cold-pressed marionberry, boysenberry, red raspberry, and blueberry seed oils. *Journal of Agricultural and Food Chemistry*, 53 (3), 566-573.
66. Peinado, I., Rosa, E., Heredia, A., Escriche, I. & Andrés, A., (2016) Influence of storage on the volatile profile, mechanical, optical properties and antioxidant activity of strawberry spreads made with isomaltulose. *Food Bioscience*, 14, 10-20.
67. Perez-Jimenez, J., Fezeu, L., Touvier, M., Arnault, N., Manach, C., Hercberg, S., Galan, J.P. & Scalbert, A. (2011) Dietary intake of 337 polyphenols in French adults. *The American journal of clinical nutrition*, 93 (6), 1220-1228. Doi: 10.3945/ajcn.110.007096
68. Peter Libby, M.D. (2007) Inflammatory mechanisms: the molecular basis of inflammation and disease. *Nutrition reviews*, 65 (suppl_3), S140-S146.
69. Pincemail, J., Kevers, C., Tabart, J., Defraigne, J.O. & Dommes, J. (2012) Cultivars, Culture Conditions, and Harvest Time Influence Phenolic and Ascorbic Acid Contents and Antioxidant Capacity of Strawberry (*Fragaria x ananassa*). *Journal of Food Science*, 77 (2), C205-C210.
70. Real, J.T., Martínez-Hervás, S., Tormos, M.C., Domenech, E., Pallardó, F.V., Sáez-Tormo, G., Redon, J., Carmena, R., Chaves, F.J., Ascaso, J.F. & García-García, A.B. (2009) Increased

- oxidative stress levels and normal antioxidant enzyme activity in circulating mononuclear cells from patients of familial hypercholesterolemia. *Metabolism*, 59, 293-298. Doi: 10.1016/j.metabol.2009.07.026.
71. Reganold, J.P., Andrews, P.K., Reeve, J.R., Carpenter-Boggs, L., Schadt, C.W., Alldredge, J.R., Ross, C.F., Davies, N.M. & Zhou, J. (2010) Fruit and soil quality of organic and conventional strawberry agroecosystems. *PLoS one*, 5 (9).
 72. Reis, J.F., Monteiro, V.V.S., Gomes, R.S., do Carmo M.M., Costa, G.V., Ribera, P.C. & Monteiro, M.C. (2016) Action mechanism and cardiovascular effect of anthocyanins: a systematic review of animal and human studies. *Journal of Translational Medicine*, 14 (1), 315. Doi: 10.1186/s12967-016-1076-5.
 73. Roglic, G. (2016) WHO Global report on diabetes: A summary. *International Journal of Non-communicable Diseases*, 1 (1), 3. Doi: 10.4103/2468- 8827.184853.
 74. Rondini, L., Peyrat-Maillard, M.N., Marsset-Baglieri, A. & Berset, C. (2002) Sulfated ferulic acid is the main in vivo metabolite found after short-term ingestion of free ferulic acid in rats. *Journal of Agricultural and Food Chemistry*, 50 (10), 3037-3041.
 75. Sarıdaş, M.A. (2018) Melezleme İslahıyla Seçilmiş Çilek Genotiplerinin Verim, Kalite Özelliklerinin Belirlenmesi Ve Moleküler Karakterizasyonu. *Çukurova Üniversitesi Fen Bilimleri Enstitüsü, Doktora Tezi*, 338.
 76. Schulz, M., Borges, G.D.C., Gonzaga, L.V., Costa, A.C.O. & Fett, R. (2016) Jucara fruit (*Euterpe edulis* Mart.): Sustainable exploitation of a source of bioactive compounds. *Food Research International*, 89, 14-26.
 77. Severo, J., de Oliveira, I.R., Tiecher, A., Chaves, F.C. & Rombaldi, C.V. (2015) Postharvest UV-C treatment increases bioactive, ester volatile compounds and a putative allergenic protein in strawberry. *Food Science and Technology*, 64, 685-692.
 78. Sharrett, A.R., Ballantyne, C.M., Coady, S.A., Heiss, G., Sorlie, P.D., Catellier, D. & Patsch, W. (2001) Coronary heart disease prediction from lipoprotein cholesterol levels, triglycerides, lipoprotein(a), apolipoproteins A-I and B, and HDL density subfractions: The Atherosclerosis Risk in Communities (ARIC) Study. *Circulation*, 104, 1108– 1113.
 79. Sorelle, R. (1999) Global epidemic of cardiovascular disease expected by the year 2050. *Circulation*, 100 (20), e101. Doi: 10.1161/01.CIR.100.20.e101.
 80. Stoner, G.D., Wang, L.S., & Casto, B.C. (2008) Laboratory and clinical studies of cancer chemoprevention by antioxidants in berries. *Carcinogenesis*, 29 (9), 1665-1674. Doi: 10.1093/carcin/bgn142.
 81. Takasawa, R., Saeki, K., Tao, A., Yoshimori, A., Uchiro, H., Fujiwara, M. & Tanuma, S. (2010) Delphinidin, a dietary anthocyanidin in berry fruits, inhibits human glyoxalase I. *Bioorganic & Medicinal Chemistry*, 18 (19), 7029-7033. Doi: 10.1016/j.bmc.2010.08.012.
 82. Tulipani, S., Armeni, T., Giampieri, F., Alvarezsuarez, J.M., Gonzalezparamas, A.M., Santos-buelga, C., Busco, F., Principato, G., Bompadre, S. & Quiles, J.L. (2014) Strawberry intake increases blood fluid, erythrocyte and mononuclear cell defenses against oxidative challenge. *Food Chemistry*, 156 (2), 87. Doi: 10.1016/j.foodchem.2014.01.098.
 83. Valentinuzzi, F., Mason, M., Scampicchio, M., Andreotti, C., Cesco, S. & Mimmo, T. (2015) Enhancement of the bioactive compound content in strawberry fruits grown under iron and phosphorus deficiency. *Journal of the Science of Food and Agriculture*, 95, 2088-2094.
 84. Walton, M.C., Hendriks, W.H., Reynolds, G.W., Kruger, M.C. & McGhie, T.K. (2006) Anthocyanin absorption and plasma antioxidant status in pigs. *Journal of agricultural and food chemistry*, 54 (20), 7940-7946.
 85. Wedick, N.M., Pan, A., Cassidy, A., Rimm, E.B., Sampson, L., Rosner, B., Willett, W., Hu, F.B., Sun, Q. & van Dam, R.M. (2012) Dietary flavonoid intakes and risk of type 2 diabetes in US men and women. *The American Journal of Clinical Nutrition*, 95 (4), 925-933. Doi: 10.3945/ajcn.111.028894.
 86. Wightman, J.D. & Heuberger, R.A. (2015) Effect of grape and other berries on cardiovascular health. *Journal of the Science of Food & Agriculture*, 95 (8), 1584-1597. Doi: 10.1002/jsfa.6890.

87. Wilkes, K., Howard, L.R., Brownmiller, C. & Prior, R.L. (2014) Changes in chokeberry (*Aronia melanocarpa* L.) polyphenols during juice processing and storage. *Journal of Agricultural and Food Chemistry*, 62 (18), 4018-4025. Doi: 10.1021/jf404281n.
88. Wojdylo, A., Figiel, A. & Oszmianski, J. (2009) Effect of drying methods with the application of vacuum microwaves on the bioactive compounds, color, and antioxidant activity of strawberry fruits. *Journal of Agricultural and Food Chemistry*, 57 (4), 1337-1343. Doi: 10.1021/jf802507j.
89. Wu, X., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Gebhardt, S.E. & Prior, R.L. (2006) Concentrations of anthocyanins in common foods in the united states and estimation of normal consumption. *Journal of Agricultural and Food Chemistry*, 54, 4069-4075.
90. Yang, H., Tian, T., Wu, D., Guo, D. & Lu, J. (2019) Prevention and treatment effects of edible berries for three deadly diseases: Cardiovascular disease, cancer and diabetes. *Critical Reviews in Food Science and Nutrition*, 59 (12), 1903-1912.
91. Zhang, H., Cao, C.M., Gallagher, R.J. & Timmermann, B.N. (2014) Antiproliferative withanolides from several solanaceous species. *Natural Product Research*, 28 (22), 1941-51. Doi: 10.1080/14786419.2014.919286.
92. Zhao, Z.D., Niu, Y., Ge, Q. & Zhang, Y. (2016) Review of Anthocyanins from *Lycium ruthenicum* Murr. *Food Industry*, 0 (8), 230-234.
93. Zhu, Y., Ling, W., Guo, H., Song, F., Ye, Q., Zou, T., Li, D., Zhang, Y., Li, G., Xiao, Y., Liu, F., Li, Z., Shi, Z. & Yang, Y. (2013) Anti-inflammatory effect of purified dietary anthocyanin in adults with hypercholesterolemia: a randomized controlled trial. *Nutrition, Metabolism and Cardiovascular Diseases*, 23 (9), 843-849.
94. Zhu, Y., Xia, M., Yang, Y., Liu, F., Li, Z., Hao, Y., Mi, M., Jin, T. & Ling, W. (2011) Purified anthocyanin supplementation improves endothelial function via NO-cGMP activation in hypercholesterolemic individuals. *Clinical chemistry*, 57 (11), 1524-1533.