

Flavonoids

Subjects: Nutrition & Dietetics | Agriculture, Dairy & Animal Science

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Flavonoids are health supplements commonly known in their tablet forms. Crops are rich in various sub-classes of flavonoids that could be used for human consumption. The biosynthesis and transport of flavonoids are major factors contributing to the accumulation of flavonoids in crops. On the other hand, the bioavailability of flavonoids to the human body governs the beneficial effects of the flavonoids on human health.

Keywords: crops ; phenolic compounds ; flavonoids ; biosynthesis pathway ; ABC transporters ; MATE transporters ; nutrition ; health

1. Background

With the improved awareness of nutrition and health worldwide, the consumption of health supplements has been ever increasing. Crops, including a variety of fruits, vegetables and legumes, are rich in flavonoids, which are known to exhibit antioxidative and antimicrobial activities.

2. The Bioavailability of Flavonoids

Various studies have suggested the potential nutritional and health-promoting effects of flavonoids. The bioavailability of different classes of flavonoids is varied. In general, the most poorly absorbed flavonoids upon ingestion are proanthocyanidins and anthocyanins, while the most readily absorbed flavonoids are isoflavones ^{[1][2]}. Ingested flavonoids experience a series of modifications, such as deglycosylation, methylation, glucuronidation and sulphation, along the gastrointestinal tract and circulatory system to yield different conjugates of flavonoids ^{[3][4]}. These modifications affect the bioavailability of the flavonoids by affecting their stereochemical configurations and enzyme specificities ^{[2][4][5]}.

3. Regulation of Flavonoid Biosynthesis

The flavonoid contents in plants are tightly regulated by a complex network of regulators. Transcription factors (TFs), including members of the MYB, bHLH, MADS, WRKY and WD40 families, play important roles in regulating flavonoid biosynthesis in plants. These transcription factors may form regulatory complexes. For example, complexes of MYB-bHLH-WD40 (MBW) have been suggested in plants such as *A. thaliana*, *Camellia sinensis*, *Fragaria* × *ananassa* and *Vitis vinifera* in order to fine-tune flavonoid levels ^{[6][7][8][9][10]}. The various combinations of the components in the MBW complex lead to yet another level of regulation in the flavonoid biosynthesis pathways. In general, plant species share common regulators involved in the early steps of the flavonoid biosynthesis pathway. However, different regulators are involved in the regulation of biogenesis genes in the later part of the biosynthesis pathways to determine the specific flavonoids produced and their levels in different plant species ^{[6][11][12][13][14]}.

4. Transport of Flavonoids

Flavonoids are found both intracellularly and extracellularly in plants. Inside plant cells, flavonoids are distributed in various compartments, including nuclei, ERs, vacuoles, vesicles and chloroplasts. In soybean, it has been reported that isoflavones are stored in vacuoles in the glycosylated or malonylated form ^[15]. On the other hand, in pea, it was found that isoflavone synthase, CYP93C18, is localized in the ER ^[16]. These patterns of intracellular storage and biosynthesis locations highlight the significance of flavonoid transport in influencing the storage and the bioavailability of flavonoids.

The transportation of flavonoids can be facilitated by vesicles or transporter proteins. One of the transporter proteins is glutathione-S-transferase (GST). GST acts as a carrier protein by binding to flavonoids. In soybean, the binding of a putative lambda class GST, GmGSTL1, to flavonoids was reported ^[17]. ATP-binding cassette (ABC) transporters and multidrug and toxic compound extrusion (MATE) transporters have been characterized in various plant species as the transporters of flavonoids ^[18]. In general, transporter proteins are integral membrane proteins which facilitate the

movement of molecules across membranes ^[19]. The specific protein domains of ABC transporters and MATE transporters which confer their functions will be discussed below. These two types of transporters mediate the secretion or the accumulation of flavonoids in plants. Since the mechanisms of secretion and uptake of flavonoids by plant cells have been discussed in previous reviews ^{[18][20][21]}, this review will discuss the transportation of flavonoids from the perspective of the nutritional contents of plants for human consumption; in other words, the types of transportation that can facilitate the accumulation of flavonoids in the edible portion of crop plants.

5. Conclusion

Common crops for human consumption, including fruits, vegetables and legumes, are rich in different forms of flavonoids. Tea, which is an important plant for making beverages in a lot of Asian countries, is abundant in catechin, a flavanol shown to have health benefits. Flavonoid molecules have similar yet different structures. The subtle molecular mechanisms in the regulation of their biosynthesis bring forth a vast variety of flavonoids and their derivatives. The different molecular structures of flavonoids give rise to the different functions of these molecules. Equally important is the transport of flavonoids in the regulation of their contents in plant cells and thus their availability for human consumption. The understanding of the biological functions of flavonoids and the molecular mechanisms regulating their abundances in food crops will facilitate the smart use of crops in our diet and enable breeding programs to produce crops with desirable contents of flavonoids.

References

1. Manach, C.; Williamson, G.; Morand, C.; Scalbert, A.; Rémésy, C.; Bioavailability and bioecacy of polyphenols in humans. I. Review of 97 bioavailability studies. *Am. J. Clin. Nutr.* **2005**, *81*, 230–242, [10.1093/ajcn/81.1.230S](#).
2. Thilakarathna, S.H.; Vasantha Rupasinghe, H.P.; Flavonoid bioavailability and attempts for bioavailability enhancement . *Nutrients* **2013**, *5*, 3367–3387, [10.3390/nu5093367](#).
3. Day, A.J.; Gee, J.M.; DuPont, M.S.; Johnson, I.T.; Williamson, G.; Absorption of quercetin-3-glucoside and quercetin-4'-glucoside in the rat small intestine: The role of lactase phlorizin hydrolase and the sodium-dependent glucose transporter. *Biochem. Pharmacol.* **2003**, *65*, 1199–1206, [10.1016/S0006-2952\(03\)00039-X](#).
4. Mullen,W.; Edwards, C.A.; Crozier, A.; Absorption, excretion and metabolite profiling of methyl-, glucuronyl-, glucosyl- and sulpho-conjugates of quercetin in human plasma and urine after ingestion of onions. *Br. J. Nutr.* **2006**, *96*, 107, [10.1079/BJN20061809](#).
5. Donovan, J.L.; Crespy, V.; Oliveira, M.; Cooper, K.A.; Gibson, B.B.; Williamson, G.; (+)-Catechin is more bioavailable than (-)-catechin: Relevance to the bioavailability of catechin from cocoa. *Free Radic. Res.* **2006**, *40*, 1029–1034, [10.1080/10715760600868545](#).
6. Matus, J.T.; Poupin, M.J.; Cañón, P.; Bordeu, E.; Alcalde, J.A.; Arce-Johnson, P.; Isolation of WDR and bHLH genes related to flavonoid synthesis in grapevine (*Vitis vinifera* L.). *Plant Mol. Biol.* **2010**, *72*, 607–620, [10.1007/s11103-010-9597-4](#).
7. Appelhagen, I.; Lu, G.H.; Huep, G.; Schmelzer, E.; Weisshaar, B.; Sagasser, M.; TRANSPARENT TESTA1 interacts with R2R3-MYB factors and aects early and late steps of flavonoid biosynthesis in the endothelium of *Arabidopsis thaliana* seeds. *Plant J.* **2011**, *67*, 406–419, [10.1111/j.1365-313X.2011.04603.x](#).
8. Schaart, J.G.; Dubos, C.; Romero De La Fuente, I.; van Houwelingen, A.M.M.L.; de Vos, R.C.H.; Jonker, H.H.; Xu,W.; Routaboul, J.M.; Lepiniec, L.; Bovy, A.G.; et al. Identification and characterization of MYB-bHLH-WD40 regulatory complexes controlling proanthocyanidin biosynthesis in strawberry (*Fragaria x ananassa*) fruits. *New Phytol.* **2013**, *197*, 454–467, [10.1111/nph.12017](#).
9. Liu, Y.; Hou, H.; Jiang, X.; Wang, P.; Dai, X.; Chen, W.; Gao, L.; Xia, T.; A WD40 repeat protein from camellia sinensis regulates anthocyanin and proanthocyanidin accumulation through the formation of MYB–bHLH–WD40 ternary complexes. *Int. J. Mol. Sci.* **2018**, *19*, 1686, [10.3390/ijms19061686](#).
10. Wu, L.Y.; Fang, Z.T.; Lin, J.K.; Sun, Y.; Du, Z.Z.; Guo, Y.L.; Liu, J.H.; Liang, Y.R.; Ye, J.H.; Complementary iTRAQ proteomic and transcriptomic analyses of leaves in tea plant (*Camellia sinensis* L.) with diereent maturity and regulatory network of flavonoid biosynthesis. *J. Proteome Res.* **2019**, *18*, 252–264, .
11. Shelton, D.; Stranne, M.; Mikkelsen, L.; Pakseresht, N.; Welham, T.; Hiraka, H.; Tabata, S.; Sato, S.; Paquette, S.; Wang, T.L.; et al. Transcription factors of lotus: Regulation of isoflavonoid biosynthesis requires coordinated changes in transcription factor activity. *Plant Physiol.* **2012**, *159*, 531–547, [10.1104/pp.112.194753](#).

12. Chu, S.; Wang, J.; Zhu, Y.; Liu, S.; Zhou, X.; Zhang, H.; Wang, C.E.; Yang, W.; Tian, Z.; Cheng, H.; et al. An R2R3-type MYB transcription factor, GmMYB29, regulates isoflavone biosynthesis in soybean. *PLoS Genet.* **2017**, *13*, e1006770, [10.1371/journal.pgen.1006770](https://doi.org/10.1371/journal.pgen.1006770).
13. Plunkett, B.J.; Espley, R.V.; Dare, A.P.; Warren, B.A.W.; Grierson, E.R.P.; Cordiner, S.; Turner, J.L.; Allan, A.C.; Albert, N.W.; Davies, K.M.; et al. Myba from blueberry (*vaccinium* section *cyanococcus*) is a subgroup 6 type r2r3myb transcription factor that activates anthocyanin production. *Front. Plant Sci.* **2018**, *9*, 1300, [10.3389/fpls.2018.01300](https://doi.org/10.3389/fpls.2018.01300).
14. Pi, E.; Xu, J.; Li, H.; Fan, W.; Zhu, C.; Zhang, T.; Jiang, J.; He, L.; Lu, H.; Wang, H.; et al. Enhanced salt tolerance of Rhizobia-inoculated soybean correlates with decreased phosphorylation of the transcription factor GmMYB183 and altered flavonoid biosynthesis. *Mol. Cell. Proteom.* **2019**, *18*, 2225–2243, [10.1074/mcp.RA119.001704](https://doi.org/10.1074/mcp.RA119.001704).
15. Dastmalchi, M.; Dhaubhadel, S.. Soybean seed isoflavonoids: Biosynthesis and regulation. In *Phytochemicals — Biosynthesis, Function and Application*; Springer Science & Business Media: Berlin, Germany, 2014; pp. 1–21.
16. Pičmanová, M.; Reňák, D.; Feciková, J.; Růžička, P.; Mikšátková, P.; Lapčík, O.; Honys, D.; Functional expression and subcellular localization of pea polymorphic isoflavone synthase CYP93C18. *Biol. Plant* **2013**, *57*, 635–645, [10.1007/s10535-013-0344-y](https://doi.org/10.1007/s10535-013-0344-y).
17. Chan, C.; Lam, H.-M.; A putative lambda class glutathione S-transferase enhances plant survival under salinity stress. *Plant Cell Physiol.* **2014**, *55*, 570–579, [10.1093/pcp/pct201](https://doi.org/10.1093/pcp/pct201).
18. Zhao, J.; Flavonoid transport mechanisms: How to go, and with whom. *Trends Plant Sci.* **2015**, *20*, 576–585, [10.1016/j.tplants.2015.06.007](https://doi.org/10.1016/j.tplants.2015.06.007).
19. Alguet, Y.; Cameron, A.D.; Diallinas, G.; Byrne, B.; Transporter oligomerization: Form and function. *Biochem. Soc. Trans.* **2016**, *44*, 1737–1744, [10.1042/BST20160217](https://doi.org/10.1042/BST20160217).
20. Zhao, J.; Dixon, R.A.; The “ins” and “outs” of flavonoid transport. *Trends Plant Sci.* **2010**, *15*, 72–80, [10.1016/j.tplants.2009.11.006](https://doi.org/10.1016/j.tplants.2009.11.006).
21. Takanashi, K.; Shitan, N.; Yazaki, K.; The multidrug and toxic compound extrusion (MATE) family in plants. *Plant Biotechnol.* **2014**, *31*, 417–430, [10.5511/plantbiotechnology.14.0904a](https://doi.org/10.5511/plantbiotechnology.14.0904a).

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