Gaps and recent advances in our understanding of anthocyanins stability during processing and shelf life: potential implications to processed products

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Objective
While numerous studies focus on identifying polyphenolic compounds, less attention was given to understanding their non-enzymatic degradation as a function of their chemical structure, with a common generalized perception of low stability and decreased antioxidant capacity upon oxidation. We aimed to provide a more comprehensive understanding by studying the most unstable group of polyphenols, anthocyanins, in simple and complex model systems. Furthermore, in addition to the degradation kinetics, we also monitored the in-vitro antioxidant capacity (TAC) to question the perception of a significant decrease in antioxidant capacity by degradation as a major anthocyanin (bio)functionality.
Methods
A set of 6 single-component anthocyanins differing in their structural features, such as the number and location of the OH-group and the presence of a conjugated sugar, and 3 multi-component anthocyanin-rich extracts as simple and complex model systems, respectively, were studied. Their degradation rate was studied using LC-MS after applying different temperatures and pressures (at pressure-stable buffers). Furthermore, the kinetics of the change in TAC was studied using FRAP and ORAC, and for some, the degradation products were identified and quantified.
Results
We have identified a higher than expected stability of anthocyanins containing a saccharide group in purified conditions, partially related to anthocyanins-polyphenols interactions such as co-pigmentation. Confirming the literature, significant structure-dependent variation was noted, with delphinidins showing significantly lower stability than pelargonidins and cyanidins. However, we also observed and quantified a significant instability of the aglycones (both chemical and physical) with a complete loss of the original cyanidin after 30 min. Interestingly, despite the structure-dependent differences in stability of the glycosides, the activation energy and activation volume were structure-independent (70.4±2.0 KJ/mol and 17.7±3.0 cm3/mol, at pH 7, respectively). Furthermore, despite the degradation, the TAC decreases only mildly, and for ORAC in a purified system does not decrease at all, as was studied for cyanidin-glycoside, showing that the degradation products can, in some cases, have even a higher TAC than the original compound.
Conclusion
Non-enzymatic degradation changes the composition of anthocyanin-rich products, yet the impact of temperature and pressure are structure independent, and more importantly, the suggested loss of antioxidant activity is mostly mild.