Understanding the formation of pinking in white wine

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Pinking can occur in certain white wines causing the turning of their color from yellow to salmon-red hue. This change was attributable to (i) small concentrations of malvidin-3-O-glucoside detected in white wines produced under reducing conditions [1]; (ii) slow dehydration of leucoanthocyanidins into the corresponding flav-3-en-3-ols; (iii) polymerization of anthocyanins under oxidative condition; (iv) combination of more than ten different monomers and polymeric compounds; (v) formation of a derivative from 2-S-glutathionyl-caftaric acid [2]. However, the formation of pinking is not completely clear. This study aimed to provide new insights on the mechanisms and the compound(s) involved in this phenomenon.

The formation of pinking was evaluated in model wine added with increasing concentrations of sulfur-containing compounds [SCCs] (i.e. glutathione, cysteine, mercaptoethanol), singularly or in combination, and fixed amounts of the phenolics (i.e. catechin and caffeic acid). An assay with copper, with and without phenolics, was also carried out. The oxidation was generated by adding p-benzoquinone under both oxic and anoxic conditions. The intensity of pink color was measured at 520 nm. A major compound associated to pinking was detected by UPLC-UV and its molecular weight and structure were investigated by High Resolution Mass Spectrometry (HRMS) and Nuclear Magnetic Resonance (NMR), respectively.

Surprisingly, in most of the conditions tested, the pink color appeared and it resulted more intense when only catechin was present. Catechin led to a faster formation of pinking even under anoxic condition. On the contrary, the color was yellow-brownish when the copper was added without and with phenolics. Considering the single addition of SCCs, the fastest appearance and major pink intensity were due to cysteine. The pinking intensity was lower with glutathione and it was not detected with mercaptoethanol. The rate of pinking formation was dependent on both SCC/p-benzoquinone and catechin/p-benzoquinone molar ratios with the former playing a paramount role. The major formation rate was observed when thiol/p-benzoquinone molar ratio ranged 0.7-1.2. The compound associated to the pink color showed a maximum adsorption at 505 nm, characteristic of anthocyanin-like moieties, and its accurate mass ($[M+H]^+$) was 450.0635 Da. NMR analysis evidenced three molecular forms in equilibrium that estimated conversion yield was 5%.

These data suggest that pinking phenomena, in our experimental conditions, is due to the oxidation of catechin with the aid of SCCs. Among the latter, cysteine, was crucial for the occurrence of color change.

References

[1] Andrea-Silva J., Cosme F., Ribeiro L. F., Moreira A. S. P., Malheiro A. C., Coimbra M. A., Domingues M. R. M., & Nunes F. M. (2014). Origin of the pinking phenomenon of white wines. Journal of Agriculture and Food Chemistry, 62(24), 5651–5659. https://doi.org/10.1021/jf500825h.

[2] Gabrielli M., Fracassetti D., Romanini E., Colangelo D., Tirelli A., Lambri, M. (2021). Oxygen-induced faults in bottled white wine: A review of technological and chemical characteristics. Food Chemistry, 348, 128922. https://doi.org/10.1016/j.foodchem.2020.128922.