A COMPREHENSIVE STUDY ON THE EFFECT OF HIGH TEMPERATURE EXTREMES ON BERRY TANNIN COMPOSITION

Julia GOUOT1,2, Jason SMITH1,3, Bruno HOLZAPFEL1,4 and Celia BARRILL1,2

1National Wine and Grape Industry Centre, Wagga Wagga, Australia.
2School of Agricultural and Wine Sciences, Charles Sturt University, Wagga Wagga, Australia.
3New South Wales Department of Primary Industries, Orange, Australia.
4New South Wales Department of Primary Industries, Wagga Wagga, Australia.

Introduction

Grapепgrowers can be informed to upcoming heatwaves thanks to the Heatwave Service for Australia provided by the Bureau Of Meteorology. They also have tools to prepare for heatwaves with a number of mitigation options available. These include hydrocooling, canopy management, sunscreen or even shade cloth to reduce direct bunch exposure to sunlight during the summer months. However, with more open spring canopies, or early leaf removal used in some vineyards, young berries may be at risk with the increasing severity and frequency of extreme heat events early in the season. It is thus essential to understand the sole effect of high temperature on berry development and composition, and compounds such as tannins whose biosynthesis starts around flowering [1]. In addition, heatwaves occurring during berry ripening have worsened with berries exposed to air temperature up to 45 °C, and reaching well above 50 °C if unprotected due to canopy damage. The objective of this project was to study the mechanistic effect of high temperatures on tannin accumulation and maturation. It aimed to provide growers and winemakers with an understanding of berry survival thresholds, to characterise the effect on the concentration and extractability of phenolics in heat-damaged berries by harvest, and to inform more cost-effective mitigation practices.

Materials & Methods

Three experiments were conducted inside a UV-transparent glasshouse during the 2016-17 and 2018-19 seasons. Using fans blowing hot air onto individual bunches without affecting light exposure [2], the effect of temperature on a range of berry growth and composition parameters was tested on well-irrigated potted Shiraz vines:

- EXP 1: high day temperature 20 days after flowering (E-L 31)
- EXP 2: day temperature intensity (Low: LT, High: HT, Very High: VHT) and duration (3 to 39 h) 15 days after the onset of véraison (E-L 36, -10 °Brix)
- EXP 3: high day temperature at two phenological stages (E-L 31 and E-L F-34/35)

In all experiments, berry samples were peeled and ground skins and seeds were extracted in 70% acetic acid and analysed by LC-MS/MS to determine detailed tannin composition (after phloroglucinolysis) [3].

Results & Discussions

Under normal conditions, berry growth exhibited a typical double sigmoid growth pattern. Berries exposed to mild heat stress showed the same pattern but were slightly smaller with differences fading by harvest. If exposed to extreme stress, even though vines were well irrigated, damage appeared quickly with first browning, necrosis, shrivelling and desiccation with a threshold that differed depending on the phenological stage (Fig. 1). In general, total tannins, expressed on a dry weight (DW) basis, exhibited maximum concentration in skin and seeds at the end of fruit set and slowly decreased until maturity (Fig. 2). Upon heating, only small changes were found in total tannin concentration whereas tannin content and profile were impacted, likely due to berry development disruption (development delayed with less skin surface and smaller and greener seeds). Potential denegulation of some genes involved in tannin biosynthesis could have occurred but the hypothesis has to be confirmed as most genes involved in galloylation and polymerisation are still unknown.

During EXP 1, heat treatments were applied for three days (+8 °C), with day maximum temperature reaching 44.8 °C. Berry size was immediately decreased under high day temperature and, while skin tannin content was only slightly lower (NS), seed tannins were considerably reduced (Fig. 3). During EXP 2, LT, HT and VHT respectively reached a maximum of 34.6, 46.0, and 52.9 °C. HT, compared to LT at E-L 36, did not significantly impact on tannin composition. However, VHT considerably impacted on berry physiology and composition, and, regardless of the treatment duration (12 or 30 h), led to berry desiccation. Tannins extracted from the dried skin were significantly reduced. While the effect on skin was substantial, seed tannins were only slightly affected. During EXP 3, the 1st heat treatment, with day maximum temperature reaching 40 °C, slightly reduced skin and seed tannins while the 2nd heat treatment, with day maximum temperature reaching 45 °C, led to berry damage and a subsequent decrease in skin tannins but no long-term effect on seeds. By harvest, skin and seed tannin content did not differ for non-damaged berries.

When content was affected by high temperature, changes in composition were also generally observed. In the skin, during EXP 1, the percentage of galloylation (proportion of epicatechin gallate subunits) was slightly increased around F=40. Contrasted results were observed after véraison with a decrease in galloylation (EXP 3). When significantly impacted, size (mDP) of seed tannins was higher in all cases (data not shown).

Conclusion

Tannins for well-irrigated Shiraz were only affected for a short period of time following three days of high temperatures unless berries were visually damaged and completely desiccated.

References


Acknowledgements: This work was supported by the National Wine and Grape Industry Centre and funded by Charles Sturt University. Travel was funded by National Wine and Grape Industry Centre. The authors acknowledge David Foster, Khi Nguyen, Jack Zyhala, Nicola Kontoudakis, Michael Loughlin, Vincent West & Luca Filannino for technical assistance.

The National Wine and Grape Industry Centre is an alliance between Charles Sturt University, the NSW Department of Primary Industries (DPI) and the NSW Wine Industry Association.