A STUDY OF SEED DEVELOPMENT AND PHENOLIC COMPOUNDS IN SEEDS, SKINS AND WINES OF VITIS VINIFERA L. cv. SHIRAZ

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Summary

This study investigated seed development, phenolic composition of seeds and skins, and sensory properties of wines made from berries of Vitis Vinifera L., cv. Shiraz that were developed and grown under different levels of sunlight intensity at the bunch zone. The study also examined the relationships between seed and berry development, and the link between berry composition, wine composition and wine sensory properties.

The experiment consisted of three main treatments comprising different levels of sunlight intensity in the bunch zone which were obtained by canopy manipulations. The treatments were as follows: i) shaded treatment (ST) (whole vine shading by wrapping vine canopies in bird nets to restrict the canopy), ii) moderately exposed treatment (MET) (no canopy manipulation) and iii) highly exposed treatment (HET) (vines canopies were divided and shoots were trained upwards and downwards). The additional treatments included i) box treatment (BT) in the 2000/2001 season (bunches in the zone of highly exposed bunches were enclosed in specially constructed boxes to exclude sunlight) and ii) reference treatment (RT) (vines in an adjacent row managed to produce high quality fruit). The experiment was conducted for two growing seasons, 1999/2000 and 2000/2001.

The degree of sunlight intensity at the bunch zone differed highly significantly (P<0.001) between treatments indicating that the applied treatments were successful in creating variation in the amount of sunlight intercepted by the grape berries. Measures of light intensity at the bunch zone showed that the fruit of ST received less than 5% of ambient (≤100 PPFU), MET 10-40% of ambient (300-790 PPFU), HET 40-80% of ambient (800-1500 PPFU) and BT 0%.

The patterns of developmental changes in fresh seed weight and dry seed weight followed biphasic curves. Grape seed growth was able to be divided into three phases: i) a phase of seed growth, ii) an intermediate phase and iii) a phase of seed drying and maturation. The definition of these phases was based on developmental changes in fresh seed weight, dry seed weight, water content, seed width and length and physical appearance of seeds that included formation of seed features and seed coat colour.
This part of the study also provided further evidence that seed and berry development occurred simultaneously and that seed development may affect berry development. It was observed that sequences of seed development coincided with sequences of berry development. Seeds reached maximum fresh seed weight and full size at the beginning of berry colouring (veraison). Maximum dry seed weight and complete formation of seed features coincided with maximum berry weight.

A seed colour chart was developed to describe and to provide a qualitative measure of the changes in colour of the seed coat. Changes in the seed coat colour during seed and berry development were highly correlated to both changes in the phenolic composition of seeds and changes in the phenolic composition of skins. The strong inverse correlation between seed coat colour values and the concentrations of extracted seed monomers and tannins suggested that during seed development seed coat and phenolic compounds underwent many chemical changes. These changes may be characterised as the natural sequences of seed maturation which lead to increased impermeability of the seed coat and seed dormancy. A hypothesis was developed about a possible mechanism of oxidation of phenolic compounds and their role in seed dormancy. Developmental changes of the seed coat colour were also highly correlated with developmental changes in the accumulation of total anthocyanins and skin total phenolics, indicating that the external appearance and colour of the seed coat may be used as an additional indicator of seed maturity and overall berry ripeness.

Different levels of sunlight intensity at the bunch zone had only a small effect on berry weight, seed weight and number of seeds per berry. Reduced sunlight intensity at the bunch zone (ST) delayed ripening and decreased the accumulation of total anthocyanins and skin total phenolics. During berry development, at the same stage of berry maturity (Brix), the concentration of anthocyanins and skin total phenolics were similar in berries developed and ripened under moderate sunlight intensity (10-40% of ambient) (MET) to those berries developed and ripened under high light intensity (40-80% of ambient).

In the two years of the experiment the modification of the degree of light interception at the bunch zone had little effect on the level and concentration of seed tannins.
The concentration and composition of phenolic compounds in the skins (anthocyanins, skin tannins and flavonoids) of berries of different treatments was compared at the stage of maximal concentration of total anthocyanins. The additional treatment of complete bunch shading (BT) was also included in this experiment; in the second season. Excluded (BT) or low sunlight intensity (<100 PPF) (ST) at the bunch zone affected the accumulation of phenolic compounds in the berry skins and the following effects were observed: i) reduced accumulation of total anthocyanins; with increased proportion of anthocyanins in the caffeoyl-glucoside form, relative to those in the mono-glucoside form, ii) reduced accumulation of skin tannins, and iii) reduced accumulation of flavonoids (quercetin and quercetin-3-glucoside).

The accumulation of total anthocyanins did not increase with increasing sunlight intensity above 30% of ambient (500-900 PPF) which could be attributed to the high temperature effect of fully exposed berries. Most sensitive to changes in light and temperature conditions were anthocyanins in the mono-glucoside form, followed by anthocyanins in the caaffeoyl-glucoside form and acetyl-glucoside form. The accumulation of skin tannins was enhanced with increasing sunlight intensity at the bunch zone until approximately 80-90% of ambient (1300 PPF). The accumulation of quercetin and quercetin-3-glucoside was higher with increased sunlight intensity at the bunch zone indicating that the production of both compounds is highly dependent on light intensity. The results from this study indicated that the concentrations of anthocyanins, skin tannins and flavonoids in the berry skins depend on complex interactions between light and temperature effects on berries. Strong relationships among the concentration of anthocyanins, tannins and quercetin and quercetin-3-glucoside in the berry skins indicated that accumulation of these compounds paralleled each other, but their coordination has yet to be established.

Wines were made from the three main treatments (ST, MST, HET) and the additional KT treatment, when berries reached approximately 23-25 °Brix. The contribution of seed components to wine made from berries of different treatments was similar within the same season. Berries from the moderately and highly exposed canopy conditions collected for winemaking had similar or higher concentration of anthocyanins and higher concentration of skin tannins. Berries of KT had higher concentration of anthocyanins and skin tannins.
Modified wine colour density, the concentration of total anthocyanins (only in the second season), polymeric pigments and tannin polymeric fraction, and total phenolics were significantly (P<0.001) lower in wines of ST than in wines of MET and HET. Wines from berries grown under moderate sunlight intensity had similar concentration of total anthocyanins and total phenolics, but higher concentration of polymeric pigments and tannin polymers than wines from berries grown under high sunlight intensity. Wines of RT were significantly higher (P<0.001) in modified wine colour density, the concentration of total anthocyanins, polymeric pigments, tannins and total phenolic than all other treatments.

The astringency-related mouth-feel sensory attributes (coarseness, grainy, puckery, adhesiveness), as well as the intensity and persistence of fruit flavour were rated higher in RT, MET and HET wines than ST wines and these effects were more pronounced in the second season.

The series of investigations provided the following information.

i) The differences in the concentration of anthocyanins in the berry skins between treatments were reflected in concomitant differences in the concentration of total anthocyanins in wines. During fermentation and wine maturation degradation of anthocyanins acylated with acetic acid was greater than those acylated with p-coumaric acid. A lower decrease in the concentration of non-acylated anthocyanins could be due to hydrolysis of acylated anthocyanins that compensated for the loss of non-acylated anthocyanins.

ii) The concentration of pigmented polymers and tannins in wines was related to the concentration and composition of anthocyanins and also to the concentration of seed and skin tannins, and the ratios (balance) between anthocyanins and tannins. Higher wine quality may be related to viticultural conditions which result in higher concentrations of anthocyanins and skin tannins in berries, coupled with a lower ratio of seed tannins to anthocyanins and a higher ratio of skin tannins to anthocyanins.

iii) Modified wine colour density was related to the concentration of polymeric pigments and anthocyanins in wines. The differences in modified wine colour density between treatments were greater than the differences in the concentration of total anthocyanins in berries.
iv) The astringency related mouth-feel attributes were related to the concentration of tannins in wines.

v) In general wines with higher concentration of phenolic compounds (anthocyanins, pigmented and non-pigmented polymers) and higher modified wine colour density were rated higher for most of the mouth feel attributes as well as higher on a quality scale.

Wine composition was related to the level and balance between anthocyanins, seed and skin tannins in berries. Excessive canopy shade was detrimental to berry composition, wine composition and wine sensory properties. In warm to hot viticultural climates adoption of practices which lead to moderate degree of bunch exposure are recommended. Thus, an assessment of canopy microclimate, in conjunction with berry composition needs to be undertaken to predict wine quality.