Use of Vis-Nir Hyperspectral Imaging to Quantify Anthocyanins, Soluble Solids, and Titratable Acidity in Grape Berries

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Abstract

Monitoring ripening is one of the most time-consuming laboratory procedures in grape and wine. The procedures are relatively long and complex and require extensive lab training and important labor expenses. The techniques are destructive and do not allow repeated measurements of the same samples. It is not possible to characterize spatial variability and the ripening process without a large number of samples thus incurring in large costs. Hence the need of finding new, faster techniques, less expensive, and able to produce spatial-temporal information to empower precise viticulture approaches.
This study attempts to assess grape skin flavonoids, total soluble solids and titratable acidity in intact berries through the use of a hyperspectral camera. The samples will be collected in different vineyards and varieties in order to ensure a large variability of target compounds. During the season 2020 we collected about 400 samples of Cabernet-Sauvignon and Cabernet-Franc berries in Madera, Paso Robles and Rutherford, California on different dates but always after veraison. Samples were composed of 20 berries each. Each sample was imaged in a dark room in the lab using a VIS-NIR hyperspectral camera (500-900nm), then peeled; from the flesh we obtained juice for measuring total soluble solids and titratable acidity, from the skins we obtained the anthocyanin profile through HPLC. The reflectance spectra of the camera were related to the content in soluble solids, acids and anthocyanins through random forest regression and good correlations were found that allowed to predict grape composition with small associated error. These models will then be deployed in field conditions by mounting the camera on a tripod, an ATV or a conveyor belt for real time monitoring of grape composition.

Background

- Monitoring ripening is one of the most time-consuming laboratory procedures in grape and wine production.
- The procedures are relatively long and complex and require extensive lab training and important labor expenses.
- The techniques are destructive and do not allow repeated measurements of the same sample.
- It is not possible to characterize spatial variability and the ripening process without a large number of samples thus incurring in large costs.
- Hence the need of finding new, faster techniques, less expensive, and able to produce spatial-temporal information to empower precise viticulture approaches.

Scope

Develop predictive models to assess grape composition (Brix, TA, anthocyanins) from hyperspectral imaging of berries and identify the most important wavelengths to foster the development of simplified sensors specifically adapted to monitor grapes in the field with reduced complexity and cost.

Materials and methods

1. Sample berries from multiple varieties
2. Hyperspectral imaging in controlled conditions
3. Chemical analysis of grape composition (total soluble solids, titratable acidity, anthocyanins)
4. Process hyperspectral images through machine learning modeling
5. Deploy models in the field on different platforms for mapping purposes

Figure 1. Hyperspectral imaging of berry samples in the lab. Hyperspectral images are acquired in a dark cabinet with a consistent light source. Berries are imaged together with a reflectance standard (here image is taken at 520nm. The datacube (Height x Width x Wavelength) is processed in a powerful workstation, pure berry pixels are extracted from the picture, and it is possible to obtain an average absorbance spectrum (here VIS/NIR), but also individual spectrum for each berry (and each pixel in a berry). These data can be used for modeling purposes.

Figure 2. Hyperspectral imaging on different platforms, on the conveyor belt of a harvester (the camera is included within the case), in front of an ATV, on a tripod.

Results

- During the season 2020 we collected about 400 samples of Cabernet-Sauvignon and Cabernet-Franc berries in Madera, Paso Robles and Rutherford, California on different dates but always after veraison.
- Samples were composed of 20 berries each.
- Each sample was imaged in a dark room in the lab using a VIS-NIR hyperspectral camera (500-900nm), and then peeled.
- From the flesh we obtained juice for measuring total soluble solids and titratable acidity, from the skins we obtained the anthocyanin profile through HPLC

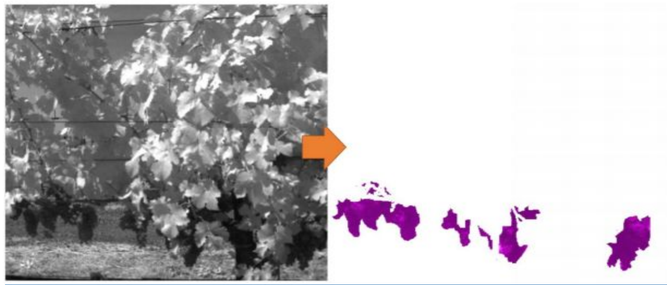

Figure 3. Hyperspectral imaging of a VSP trellised grapevine (here we show 720 nm) and segmented grapes

Figure 4. Example of hyperspectral imagery from the harvester conveyor (here at 640nm). The white circle on the right is a reflectance standard.

Conclusions

- The use of hyperspectral imagery has given interesting results in other viticulture regions of the world. This is the first time a similar technology is tested in the conditions of California, which presents significant differences in sun radiation and trellis systems. This is a two year projects that is just about to start and we are thankful to the American Vineyard Foundation for funding it.