PREMIVM – improving grape quality with multiparametric field analysis of grapes and leaves in vineyards

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ABSTRACT

European wine industry is a strategic economic sector that is nowadays facing a growing competition in the international market at the same time it as to deal with predictable lower support from the CAP. Taking into consideration that the use of ICT can support the development of new tools and devices that can reduce costs and increase final product quality/quantity an international consortium that comprises 3 technical companies and 3 winegrowers together with 3 research groups setup the EU Project PREMIVM. In this work will present the PREMIVM decision support system that was developed including the field device for data collection - WINEPEN, the web information management system for data storage, processing and information visualization, and the smartphone interface for information delivery.

Keywords: Grapevine, Ripeness detection, Web DSS, information system

1. INTRODUCTION

In August 2009 was fully implemented the reform of the Common Market Organization (CR Nº 479/2008, 29-04-2008). It aims at minimizing the surplus of basic low quality wine, reducing EU subsidies and making EU wine more competitive. This reform, the inevitable disappearance of EU subsidies together with the recent economical crisis, more demanding consumer trends, the competition of New World producers and uncertainties caused by climate change, will put into risk a significant number of EU winegrowing SME´s.

To survive, EU winegrowers will have to increase crop value (grape quality), reduce the production volume of basic wine and convert part into premium quality. This can be achieved by implementing effective field control methods that avoid the common problem of mixing under-ripe and over-ripe grapes, main cause for the production of poor quality wines. Currently vineyard variability is controlled through visual

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inspection, grape tasting, expensive and laborious laboratory analysis and the use of traditional handheld refractometers.

Taking into consideration that the use of ICT can support the development of new tools and devices that can reduce costs and increase final product quality/quantity an international consortium that comprises 3 technical companies and 3 winegrowers together with 3 research groups setup the EU Project PREMIVM.

PREMIVM proposes a solution based on proven laboratory experimentations performed by partners of the consortium: WINEPEN - a low-cost, handheld device capable of non-invasively estimating sugars, chlorophyll, polyphenols and nitrogen in grapes and leaves. All this in the vineyard, by means of the innovative use of chlorophyll fluorescence and reflectance multispectral data correlated by specific mathematical models, with GPS tags for all readings. The measurement principle is based on the natural response of vegetal species to light, where specific molecules are excited at a certain wavelength and emit radiation of a different wavelength. The emission spectrum provides qualitative and quantitative data that can be used by vineyard managers to precisely control the field, reduce vineyard variability, define optimal harvesting times and increase production value

2. MATERIAL AND METHODS

In order to remain competitive in the world market EU winegrowers will have to increase crop value (grape quality), reduce the production volume of basic wine and convert part into premium quality. This can be achieved by implementing effective field control methods that avoid the common problem of mixing under-ripe and over-ripe grapes, main cause for the production of poor quality wines. To contribute for solving this problem the European Project PREMIVM (www.premivm.eu) was setup and proposes a solution based in s web decision support systems that includes a low-cost, handheld device capable of non-invasively estimating sugars, chlorophyll, polyphenols and nitrogen in grapes and leaves - WINEPEN.

2.1 Premivm principles

The principle behind PREMIVM project is a measurement of spectral properties of photosynthetic active samples. Incoming sunlight can be reflected (reflectance, R) absorbed or transmitted by the sample. Absorbed light is primarily used for photosynthesis, but in parallel part of the absorbed energy is emitted in form of heat or re-emitted in form of chlorophyll fluorescence (Chl-F) (Fig. 1). This natural response to light by plant species is the basis for creating specific spectrochemical methods of analysis like fluorescence and reflectance where basically the molecules of the analyzed contribute to the specific spectral properties of the sample. The emission spectrum provides information for both qualitative and quantitative analysis (Carter et al., 2001).

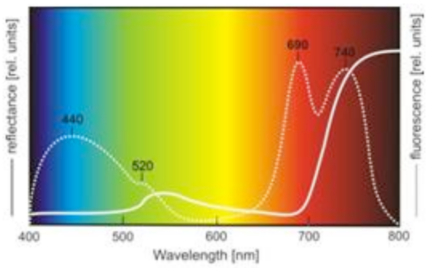

Figure 1 - Reflectance and Fluorescence spectrums for chlorophyll

Reflectance signal represents the incoming irradiance not absorbed and thus not used by the photosynthesis in the sample. Since the absorption of radiation in the different ranges of the spectrum depends on the molecular structure, reflectance can be taken to identify a chemical compound in the sample surface from close to remote distance (Card et al., 1988). The reflectance of wine leaves and grapes in the visible range of the spectrum (400 to 700 nm) is influenced by the absorption bands of the chlorophylls, carotenoids and partially by anthocyanins. The analysis of these pigments allows monitoring health, disease, stress and ripeness of the plants (Gausman and Quisenberry, 1990). When measuring intact plant material one must take into account that the formation of chlorophyll/carotenoids-protein complexes and scattering and internal reflectance of cells and cell organelles leads to slight changes of the absorption characteristics of these pigments compared to the reference pigments dissolved in a solvent (Vogelmann, 19939.

The reflectance of leaves and grapes in the UV range of the spectrum (below 400 nm) is non-specific and too low and to detect characteristic absorption bands. In the near infrared (700 to 1400 nm) the reflectance signal is influenced by scattering within the plant tissue which can be taken as an indicator of stress. In the medium infrared (1400 to 8000 nm) the signal is influenced by absorption bands of water and other mostly unspecific compounds (lignin, cellulose) (Hunt and Rock, 1989).

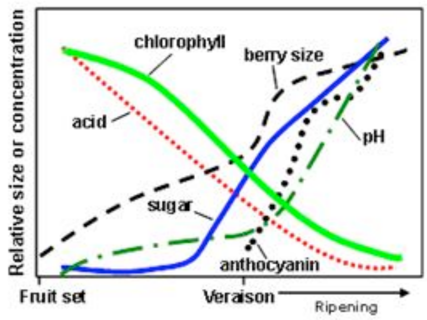

Figure 2 - Grape ripening process, during which grape chlorophyll decays. This can be correlated with ripeness parameters.

This natural response to light by plant species is the basis for creating specific spectrochemical methods of analysis like fluorescence and reflectance. The emission spectrum provides information for both qualitative and quantitative data that can be used by vineyard managers to precisely control the field, reduce vineyard variability, define optimal harvesting times and increase production value. The key is to manage locally the fine and delicate balance between yield and quality and to differentiate the vineyard area. This can be done by controlling the main parameters that define grape ripeness (sugar content, polyphenols, and chlorophyll) and plant condition (nitrogen, chlorophyll).

2.2 Field device for data collection - WINEPEN

The WINEPEN instrument is produced by one of the partner´s project Photon Systems Instruments [PSI, Brno, Czech Republic]. The instrument is a low-cost, handheld spectrophotometer with touch screen display with the capability to make wavelength and intensity readings of fluorescence and reflectance. The spectral response half width is 9 nm with integration time up 5 ms to 10 s. It has a memory capacity up to 8000 measurements with a battery life of 48 hours of continuous operation. The dimensions are: weight: 255 x 75 x 40 mm with 300 g of weight.

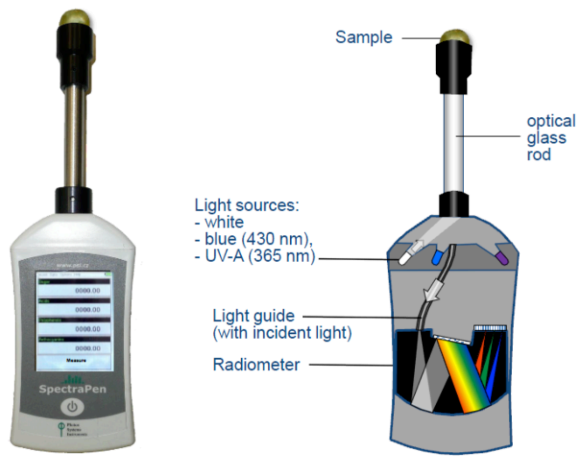

Figure 3 - WinePen

2.3 Data Collection

Before each field data collection, the user should calibrate, preferably at home to avoid penetration of full sunlight to detector during calibration. For measure the grapes the user just has to point the sample holder to the bunch and press measure. To measure the grapes collected for lab trials the user has to put the grape berry and place it into the sample holder and press measure button.

Figure 4 - Berry in the winepen

A progress bar will show the status of the measurement and the information in the display. One measure will take approx. 10 second and when finished the user can proceed with the next sample because the data will be saved automatically. After the user completes the measurement the instrument is connected to the computer with a usb cable and download the data collected using a desktop software created for that purpose.

3. PREMIVM INFORMATION SYSTEM

Premivm created a decision support system (Figure 5) including WINEPEN, an easy to use device capable of non-invasively quantifying sugar, polyphenols, chlorophyll and nitrogen content in grapes and leaves.

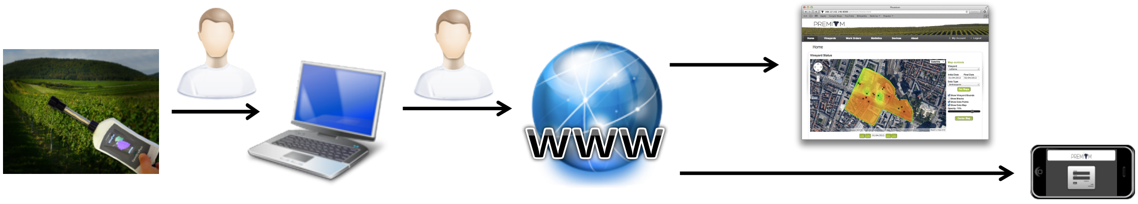

Figure 5 – Premivm Information System

All field readings made with WINEPEN will have a GPS tag, giving the user total liberty to easily extend their previously implemented sampling schemes. When uploaded to the PREMIVM vineyard management software, the data will generate easy to interpret spatial field analysis information accessible on the Web.

The Premivm DSS can be used to optimize the growth/ripening of grapes, reduce vineyard variability, define optimal harvesting time, set differential harvesting schemes, select proper grape variety/terroir combinations, micromanage local differences in the vineyard and assist integrated agriculture practices.

Two versions of the application were released since two different profiles of users have been envisaged. On one side, a standalone application was developed for users that want to store the data in their own computer, this application does not allow the user to access remotely the stored information and, according to that, was not require an internet connection. On the other hand, a web layer was also developed. This web application fed with information sent from the computer in which the device will be connected by a USB connection. In this case, an internet connection is required and the application allows remote access. The software modules in charge of receiving information from the device, processing it, database access and correlation modules will be shared by both applications.

The PREMIVM DSS stores automatically the data uploaded from the device, storing and ordering it according to the date and the position of the readings. After the user sends the data to the web application the software generates a map of each vineyard so that the end-user can visually see what is happening (for example using a color code to represent the phenolic maturity in different locations of the vineyard)

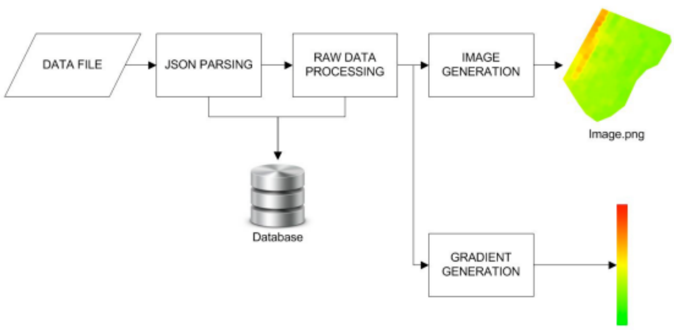

Figure 6 - Map generation process

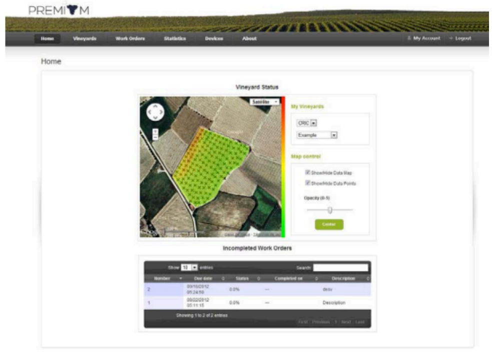

Figure 7 – Home page web application

The DSS is capable of generating easy to understand statistical analysis. For example a winegrower could draw a graph to see the evolution of phenolic maturity in given a area of the vineyard. Or the winegrower could have one of his/her employees taking readings in the field, and this person would then plug the device to a computer and the data would upload automatically with a single click.

Finally, a smartphone interface was also developed in order to make available a mobile information access channel that can be extremely valuable for decision making in the field.

4. CONCLUSIONS AND FUTURE WORK

The results obtained in the first measuring campaign with the new WINEPEN demonstrated that this device is suitable for the application in non-invasive detection of photosynthetic pigments and polyphenols contents in berries and thus for fast estimation of grapevine ripening. A development of correlation library between the PREMIVM instrument and destructive chemical analysis of standard „quality“ parameters was made with the aim of studying if the PREMIVM instrument measurements replace destructive chemical analysis. The fast data acquisition of the new instrument makes it superior over the time-consuming traditional mostly destructive chemical analysis used in today's vine growing management (Navratil and Buschman, 2012).

We believe that the overall PREMIVM platform integrating the WINEPEN, the Web vineyard management software and the smartphone interface delivers a very promising solution based in a low-cost hand-held, and non-invasive optical sensor for multiparametric field analysis of grapes and leaves in vineyards. In that sense we are using the current growing season to undertake intensive field trials of the equipment and DSS in order to optimize its use and incorporate any necessary improvement in the version we plan to offer in the market shortly.

5. ACKNOWLEDGEMENTS

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