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EGYETEM**

SZENT ISTVÁN UNIVERSITY  
FACULTY OF FOOD SCIENCE  
DOCTORAL SCHOOL OF FOOD SCIENCE

**OPTIMAL TECHNOLOGICAL ANALYSIS OF THE PINOT VARIETIES**

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## 1. INTRODUCTION

Wine quality is primarily determined by the production site (soil conditions, land relief, exposure, climatic features), the grape variety and clone, grape growing technology and vintage. Complex regulation systems based on several decades', in some cases several centuries' observations and habitat assessments have been introduced in the most successful wine growing regions throughout Europe to determine what varieties to cultivate in certain areas and what cultivation methods to be applied in order to obtain the best possible wine quality.

The Balaton Wine Region was established by 6 wine growing areas connected to Lake Balaton June 3, 2005 in Badacsony. This wine region covering almost 10,000 ha of vineyard area is one of the most important grape growing areas in Hungary, where grape and wine culture is in a privileged position. The micro-climate and soil conditions characteristic of the area provide a suitable background for the production of quality wines.

On the one hand the wines of Badacsony, Balatonboglár, Füred-Csopak, the Káli basin, the Balaton-mellék and Somló have tided over both professionally and business-wise the change of regime and have more or less maintained their market position. On the other hand, however the bottled wine exports from the area decreased dramatically between 2002 and 2010. There are different reasons for the loss of position. The most common and long term reason is probably that in a globalized, increasingly centralised commerce there is a need for larger, homogenic lots, concerning grape variety and growing region, which can hardly be supplied by wineries based in small, morselled Balaton wine growing areas. There has been no loss of position in the domestic market yet, but the centralisation going on in commerce has already called for the different wine growing areas' co-operation on the regional level.

We can achieve new market positions in two different ways. Either by developing special local varieties, by presenting unique propositions to the wine world, which are specific to Hungary or by joining in world tendencies, regarding varieties, producing such high quality standards, that cannot be obtained elsewhere. Research was already underway on the two principal 'Hungarian' varieties, i.e. Olasz rizling and Kéknyelű within the framework of a Jedlik Ányos project in the area in 2008. It seemed however logical to start intensive research activities on international varieties as well, especially since they represent a substantial vineyard surface in the Balaton Wine Region.

Taking into account recent developments on the various wine markets in the world it can be established that the trend for Chardonnay as well as Cabernet Sauvignon is over, both Sauvignon Blanc and Merlot have decreased in popularity and the new fashion will probably take consumers to Pinot Gris (Pinot Grigio) among white wines and to Pinot Noir among red varieties. Since both varieties – Szürkebarát and Kékburgundi in Hungarian – are heavily represented in the vineyard area of the Balaton Wine Region and Pinot Blanc, a variety less known, but providing the best quality is also cultivated in all its districts, all conditions were given to focus on these varieties when developing a new image for the Balaton Region. The more so, since all three belong to mid ripening varieties.

Szürkebarát has always played an important role in all the wine districts of the region. Badacsony wine district is unthinkable without this variety. However these wines are little known outside Hungary and have not yet taken their deserved position due to newer wine trends in the globalising Hungarian wine market either. Szürkebarát, Pinot Blanc and Pinot Noir are varieties are cultivated in each of the region's wine districts, however the applied grape growing and wine making technology has not yet been adapted to the production site or the production purpose yet.

The three a.m. varieties belonging to the Pinot family complement one another in satisfying various demands: they lend themselves to be vinified into fresh, fragrant, fruity wines, as well as traditional, full-bodied wines, provided the growing site and the applied growing technology are appropriate. The actual product portfolio of the region is primarily based on white wines. Due to ecological features it would not be wise to change this white wine image of the region fundamentally, but at the same time strong demand for locally grown red wine specialities has emerged. This demand can be satisfied, in my opinion, by increasing the vineyard area of Pinot Noir.

The name Pinot Blanc is rather well-known abroad, and there is a constant demand for wines of different styles made from these grapes. We can assume, that based on the need for expanding the product portfolio of the Balaton Wine Region, created by growing wine tourism in the region, this varietal wine could find its position in the premium segment, provided the appropriate variety specific grape growing and wine making technology has been developed.

I have joined into a current experiment carried out by six consortium members in the framework of a Jedlik Ányos project with the objective of developing the grape growing and wine making technology of the varieties of the Pinot family (Pinot Gris (=Szőrkebarát), Pinot Blanc, Pinot Noir) in order to produce new, innovative wines adapted to the image of the Balaton Wine Region that are able to successfully compete in the marketplace. Within this wide ranging programme my research activities aimed at examining the fine composition of the varieties belonging to the Pinot family and at determining the optimal selection of technological possibilities (fermentation, ageing) to be applied.

The selection of topic is justified by the fact that nowadays there is a growing demand for informing the consumers about the fine composition (aroma profile, acid composition, polyphenols) of wines and the beneficial effects of those components on the human body. Since the project included several wine districts in the Balaton Wine Region, I had the opportunity to examine wines originating from different growing areas.

## 2. OBJECTIVE

1. The main objective of my activities is to develop the grape growing and wine making technology of wine types harmonizing with the image of the Balaton Wine region, based on varieties (Szürkebarát, Pinot Blanc, Pinot Noir) belonging to the Pinot family.
2. Furthermore I intended to develop one or more innovative, competitive new products. My thesis includes the assessment of the potential growing areas, the comparative analysis of the varieties and their clones to achieve the desired wine character as well as vinification experiments adapted to each wine type.
3. In the course of the current dissertation suggestions are made on how to develop the image of the Balaton Wine Region with respect to the characteristics of the terroir, on the description of the rules of origin protection related to the flagship wines of the region providing a firm basis for aggressive, efficient regional wine marketing activities.
4. The thesis deals with the analysis of the extent of influence of
  - selected yeast,
  - the various clones of the varieties,
  - the DMR (transection of bearing cane),
  - grape processing and different fermentation methods,
  - in the case of Pinot Noir the period of maceration on the skins, the technological direction (red wine or rosé wine), the fermentation method on the amount of *shikimic acid, quercetin* and *resveratrol*, *total polyphenols*, *leucoantocianin*, *catechin*, *epicatechin*, *tyrosol*, *anthocyanins* and *major biogenic amines* and *metal ions* in the wine.

### **3. EXPERIMENTAL MATERIALS AND ANALYTICAL METHODS**

The present dissertation includes analyses of the wine quality and changes in the fine composition of the 3 varieties (Szürkebarát, Pinot Blanc és Pinot Noir) belonging to the Pinot family due to different technological interventions in the field of grape growing and wine making. The research was carried out between 2008 to 2010 and covered 3 wine districts (Badacsony, Balaton-felvidék and Balatonboglár) of the Balaton Wine Region.

#### **3.1 Experimental syllabus**

The objective of the industrial scale vinification (meso vinification) experiments was to establish a scientific basis for developing the grape processing, vinification and wine maturing technologies best suited to bring into prominence the innate value of the varieties belonging to the Pinot family and for creating new, innovative wine products. Experiments were carried out in year 1 on the levels of micro and meso vinification, which means that treatments were applied to 30 to 50 L and 300 L lots. From year 2 industrial scale lots were also prepared at wineries participating in the project.

##### **3.1.1. Experiments with Szürkebarát (Pinot Gris) variety**

As Pinot Gris is the most popular and most cultivated grape variety among the varieties of the Pinot family in the Badacsony wine district, it was evident to place this variety in the focus of the research activities.

###### **3.1.1.1. Experiment to determine the optimum harvest date**

„early harvest”,	average 17,5 MMo (Hungarian must degree);
„normal harvest”	average 19,5 MMo (Hungarian must degree);
„overripe condition”	20,5-21 MMo (Hungarian must degree).

###### **3.1.1.2. Grape processing, fermentation experiment**

Experiments were conducted at Varga Pincészet Kft. in Badacsonyörs in the field of grape processing and fermentation to determine the impact of quick processing and mash maceration, as well as fermentation in stainless steel containers or in new barriques on wine quality.

Quick processing: after harvest grapes were delivered in the quickest possible way, adding dry ice (in order to exclude oxidation) to the processing area, where they were destemmed and

pressed still kept cold. Mash maceration: after destemming berries were kept in mash condition and were macerated by gentle stirring for 6 hours.

### **3.1.1.3. Experiments with aging wines**

The effects of three aging methods, fast bottling, maturing (storage) in stainless steel tanks and barrel aging were compared.

### **3.1.1.4. Experiment on applying selected yeast**

Objective: To select yeast species from yeast types used in up to date wine making contributing to the development of high quality Szürkebarát wines of individual character at the Badacsony Research Station.

- a<sub>1</sub> Using selected yeast for primary aroma release: UVAFERM 228; 20g/hl
- a<sub>2</sub> Using selected yeast for secondary aroma release: UVAFERM SC; 20g/hl
- a<sub>3</sub> Using neutral selected yeast: UVAFERM CM; 20g/hl
- a<sub>4</sub> Control sample (without using selected yeast)

### **3.1.1.5. Experiment on applying the DMR-method (*double maturation raisonnée*)**

Secondary maturation method, by transecting the fruit cane about 15 to 20 days before harvest. Due to this intervention the natural circulation of materials ceases in the plant, therefore a part of the berry's water content evaporates through the skin and the solid content (acidity, sugar, etc.) concentrates.

The purpose of the experiment was to diminish the production risks of sweet, full-bodied, traditional type Szürkebarát wines.

### **3.1.1.6. Clone analysis**

The organoleptic and fine composition analyses of different Szürkebarát clones (B10, B10/5, B10/10, Kt.1, C52, GM 27, 49/207) at the Badacsony Research Station.

## **3.1.2. Pinot noir**

### **3.1.2.1. Experiment on the possible uses of the variety**

Based on the various utilization possibilities of the variety experiments were set up to find out if the production of rosé or red Pinot Noir varieties served the development of a unique, characteristic Balaton wine image.

### **3.1.2.2. Experiment on the application of the DMR-method**

Many growers use this method for white varieties, however it has little popularity among growers of reds in Hungary. Observing the development in consumer demand, it is striking that there is a growing demand for natural sweet wines which could be largely satisfied introducing this technology.

### **3.1.3. Pinot blanc**

#### **3.1.3.1. Experiment on grape processing**

Hyper oxidation: after pressing the grapes the must was exposed to intensive oxidation, no antioxidants were used at grape processing in order for the enzymes responsible for oxidation to be able to act already in the must, so they didn't cause any further oxidation problems in the wine.

Hyper reduction: berries, right after harvest, but most of all must was protected from harmful oxidation by inert gas (Nitrogen), antioxidant was applied from the start (Aromax in a dose of 20 g/HL, the product contains 50 % ascorbic acid and 50% Potassium metabisulfite). Because of its hypersensitivity the wine was stored exclusively in floating lid tanks.

Control: grapes and must were not exposed to any kind of treatment.

## **3.2. Analytical methods**

### **3.2.1. 'Routine' wine analyses**

Reducing sugar levels in musts and wines were analysed by the Rebelein-method according to MSZ 9479-1980 standard, titratable acidity according to MSZ 9472-1986 standard, extract contents were measured by the pycnometer method, following MSZ 9463-1985 standard, pH level by potentiometrics according to MSZ 14849-1979, while alcohol contents were determined in accordance with MSZ 9458-1972.

### **3.2.2. Organoleptic assessment of examined wines**

Organoleptic assessment of examined wines took place, depending on the type of the experiment, in April to June in the year following the harvest year. The wines were twice racked and clean. Tastings were attended by well-known experts, panels consisted of minimum 20 people. The 20 point positive method, according to TÖRÖK et al (2001) was used at the anonymous wine assessment.

### **3.2.3. Instrumental wine analyses**

The characteristic flavours and aromas, aroma components, polyphenolic composition, and acid composition of the different varieties grown on various growing sites were examined by using instrumental (HPLC) technique. The analyses of the aroma and acid profiles as well as polyphenol composition of the batches originating from three wine districts provided data for describing the differences among the growing sites, and useful information for origin control. The results permitted to have a closer view on the beneficial health effects of wines, i.e. the contents of resveratrol, shikimic acid and quercetin.

#### **Defining total polyphenol concentration**

By applying Folin-Ciocalteu reagent, gallic acid calibration, according to MSZ-9474-80 standard.

#### **Defining leucoantocianin concentration**

By spectrophotometry after heating a 40:60 mixture of hydrochloric acid butanol containing iron (II) sulphate (AUBERT, 1970, modified).

#### **Defining antocianin concentration**

Measured at 550 nm with spectrophotometer, after dilution with 96% ethanol containing 2 V/V % concentration of HCl-t. (AUBERT, 1970, modified).

#### **Defining catechin concentration**

In wine diluted with alcohol reacted with sulfuric vanillin, at 550 nm with spectrophotometer (TANNER, BRUNNER, 1979, modified).

#### **Defining colour intensity**

According to SUDRAUD (1968) with spectrophotometer.

Colour intensity of red wines equals to the sum of the absorbance value of the wine measured at 420 and 520 nm.

#### **Defining the hue (colour tone)**

According to SUDRAUD (1968) by spectrophotometry.

The hue of red wines is the ratio of the absorbance value of the wine measured at 420 and 520 nm.

#### **Degree of polymerization**

After the discoloration of the monomer anthocyanins by SO<sub>2</sub>, measuring two absorbance values as at defining the hue. (SOMERS, 1971).

#### **Defining (+)-catechin and (-)-epicatechin content**

With HPLC-technique, applying a method worked out at the Department of Oenology (KÁLLAY, 2010).

**Defining resveratrol content**

HPLC-technique, applying a method worked out at the Department of Oenology (KÁLLAY-TÖRÖK, 1997).

**Determining shikimic acid content**

By HPLC-technique

**Determining quercetin content**

By HPLC-technique

**Determining metal content**

With the help of ICP technique, spectrophotometry using plasma burner (ICP-AES).

**Determination of biogenic amine content**

With HPLC-technique, applying a method worked out at the Department of Oenology (KÁLLAY-NYITRAINÉ, 2003).

Results were evaluated by the statistical method of one-factor analysis of variance.

## 4. RESULTS

Based on the organoleptic assessment of the wines made in the vintage years 2008, 2009 and 2010 the following conclusions can be drawn:

### **4.1. Findings of the sensory evaluation related to the effects of different grape growing and wine making, wine aging technologies on the quality of Szürkebarát**

Based on the results of the experiments set up at Borbély Winery to determine the relation between the optimal harvest time and the berries' quality for vinification it can be established that complex, harmonious premium Szürkebarát wines can be made from grapes harvested after full ripening, however the berries should not be shrivelled yet. At the experiments of grape processing and fermentation conducted at Varga Pincészet the best results by far – with a significant difference in 2009 – were obtained by fast processing (because of rot and an increased level of pinkness), with hyper oxidation technology, and fermenting in stainless steel tanks. Among the different ways of aging the wines carried out at Kál-Vin Kft. the aging (storage) in stainless steel tanks was considered giving the best result based on the tasting results. However it was not possible to support this mathematically at a significance level of 95 %.

### **4.2. Examining the effects of different grape processing and wine making technologies on the quality of Pinot noir varietal wines**

Experiments carried out at Garamvári Szőlőbirtok St. Donatus Pincészet and at Varga Pincészet confirmed the possibility of multi-purpose utilization of the Pinot Noir variety, since apart from making red wines it lends itself very well to being vinified by the rosé and the 'white wine' technology as well.

Examining the optimum technology of on the skins fermentation of Pinot Noir wines (7-10-15 days) at Varga Pincészet the conclusion can be drawn that for light red wines it is necessary to ferment the juice on the skins for at least 10 days. For more full bodied, complex red wines it is better to extend the period to 15 days. Experiments with cold-maceration technology

conducted at Varga Pincészet to further develop the rosé vinification technology resulted in more fragrant rosé wines richer in fruit esters, deeper in colour, however still keeping their young and fresh character with significant organoleptic differences.

#### **4.3. Examining the effects of various grape processing and wine making technologies on the quality of Pinot Blanc varietal wines**

Based on the tasting results of the 2009 and 2010 vintage wines originating from the grape processing and vinification experiment conducted it can be asserted that the qualitative values of the Pinot Blanc variety are best brought into prominence by the fast processing technology combined with hyper reduction, fermented by selected yeast culture with  $\beta$ -glucosidase activity. This finding is also supported by variance analysis.

#### **4.4. Examination of the effects of different selected yeast cultures used during fermentation on the quality of Szürkebarát wines**

In order to select yeast cultures resulting in premium quality Szürkebarát wines with individual character mesovinification experiments were carried out at the PEAC SzBKI (Research Institute for Viticulture and Oenology) in 2009 and 2010. The wines were subject to organoleptic assessment at the BCE Department of Oenology, evaluated according to the 20 point evaluation system and by profile analysis. Samples originating from fermentation with primary aroma releasing yeasts fared significantly better.

#### **4.5. Defining analytical parameters of experimental wine samples**

Routine analytical results highlighted higher titratable acidity content and lower pH values in white wines in general. Except for the wines in the DMR experiment alcohol contents are lower than in previous vintage years, due to the lower must degree values because of poor weather conditions.

The fine analytic examination of the wines in the experiments was carried out by the BCE Department of Oenology. The concentration of the most important compounds having positive physiological effects, typically those of antioxidant nature (total polyphenols, leucoanthocyanin, resveratrol, shikimic acid, quercetin, catechin, epicatechin, tyrosol, anthocyanin, biogenic amines) was measured by HPLC technique. In addition metal ion content in wines was measured by AAS. Both hue and colour intensity were subject to examination in the case of red wines. Among the examined parameters significant differences

could be observed only in the case of physiologically beneficial Mg and K concentration. The Badacsony growing area, as a technological element the DMR method, cluster thinning, grape processing with maceration, combined with hyper reduction as well as 10 vs 15 days of fermentation on skins in the case of red wines had positive impact on the above two parameters. As to the compounds of polyphenolic character the results of the analyses in the case of all three varieties belonging to the Pinot family showed in general higher concentration levels in both years for the Pinot Noir variety, even in the case of shikimic acid and quercetin, usually more typical in white wines. With respect to the applied wine making technologies it can be established that 'reductive' technologies preserve these compounds to a higher degree, which is primarily demonstrated by a full bodied taste. Maceration and fermentation on the skins also add to the concentration of these compounds, which can be seen in the high values obtained after 15 days fermentation period. It is rather interesting that an rise in the concentration of shikimic acid and quercetin, usually mentioned side by side because of their positive impact on bird flu, could be observed exclusively in the case of this part of the experiment, parallely with the increase in the fermentation time, especially in the case of the 2009 vintage year.

For biogenic amines it can be stated that almost all treatments applied to the wines produced in the experiment resulted in histamine concentrations reaching the threshold limit of (2 mg/L) in Germany and (3,5 mg/L) in the Netherlands. Based on the reference literature as well as our own experience that threshold limits in the am countries are unrealistically low, almost unachievable.

Secondary ripening (DMR) has beneficial effects on serotonin, having positive influence on the human physiology. Based on our experiments the variety Pinot Blanc produces higher amounts compared to the other Pinot varieties.

#### **4.6. Comparative analysis of different clones with the aim of improving wine quality**

Based on the results of the sensory assessment of Szürkebarát wines produced in the framework of small plot growing experiments at the Research Institute for Viticulture and Oenology in Badacsony in the years 2009, 2010 and 2011 it can be stated that local clones (B.10, B.10/5, Kt.1.) were significantly higher rated and received better marks. B. 10/5 clone achieved an outstanding result even in a poor vintage year. Clones . 10/10 and B. 10/5 were officially recognized, partly due to the contribution of the present project.

#### **4.7. Applying the secondary ripening method to the Pinot varieties**

The adaptation of the DMR method for Szürkebarát and Pinot Noir was introduced in the experiment at small plot level at the Research Institute and on industrial scale at the different wineries, members of the Consortium with the hope of developing new products. Organoleptic assessment in the case of the 2009 and 2010 vintage wines brought clear evidence of the extremely favourable impact of the method on wine quality. The analysis of the fine composition of the wines also supported that this method based on artificially shrivelling the grapes by transecting the cane increases the concentration of valuable components in berries. Harvest results even in the poor 2010 vintage year showed that clearly higher sugar and acidity concentration can be achieved by applying the DMR method at considerably lower risk level than in the case of late harvesting.

Based on the results of the two sample T-test it can be reported that significant differences could be observed among the results of treatments in all three years in favour of DMR technology.

## **4.8. NEW SCIENTIFIC RESULTS**

### **4.8.1. The development of optimal wine making technologies**

It is clear from these results that complex, harmonious, premium Szürkebarát (Pinot gris) wines can be made with grapes harvested after full ripening, however not shrivelled yet. This finding was supported in both years (2009 and 2010) statistically evaluated.

I also found that local clones (B.10, B.10/5, Kt.1.) fared significantly better at organoleptic evaluations in all vintage years.

Samples fermented with the help of yeasts enhancing the release of primary aromas fared significantly better than others at wine tastings.

At the experiments of grape processing and fermentation the best results by far were obtained every year – with a significant difference in 2009 – by fast processing (because of rot and an increased level of pinkness), with hyper oxidation technology, and fermenting in stainless steel tanks.

Among aging methods maturation (storage) in stainless steel containers was appreciated most at organoleptic wine assessments throughout the examined three vintage years, however no significant differences in the given scores could be observed..

The results of the organoleptic assessment showed significant negative difference regarding 7 day fermentation on the skins. Based on these results it can be established that min. 10 days of fermentation on the skins are needed in making Pinot noir red wines.

#### **4.8.2. The development of new wine making technologies together with DMR technology**

##### **Premium Szürkebarát (Pinot gris) wine speciality containing high amount of residual sugar (PDO)**

- Usage of clones: it is recommended to use local clones or clones selected among ecological circumstances similar to those in Hungary (Szürkebarát B. 10; B. 10/10; B. 10/5; Kt. 1)
- Harvest time: this technology is based on late harvest; overripe, shrivelled grapes are harvested (at 24-26 MM<sup>0</sup>). Canes are transected at 'normal' harvest time and depending on weather conditions, grapes are harvested about 15 to 25 days later.
- Grape processing, must clarification, fermentation: overripe grapes harvested by hand into plastic containers are destemmed and crushed, then macerated for 14 hours at a temperature of 16 to 18 °C by adding 1g/q Lallzyme HC extractive enzyme before must is obtained by gentle pressing (at max. 1.8 bar). Hyper oxidation is inevitable because of the am variety characteristics (increased level of pinkness). Juice is left to settle in containers provided with cooling (maybe also heating) appliances for 10 to 14 hours at 12 to 14 °C. The settled, clean must is racked into isolated fermentation tanks with cooling option, and is fermented by adding selected yeast (UVAFERM SVG) – enhancing fermentation in spite of the high sugar content – sensitive to alcohol in the amount of 30g/HL, yeast nutrient UVAVITAL 10+10 g/HL at the temperature of 16-18 °C.

##### **Premium Pinot noir red wine speciality containing high amount of residual sugar (PDO)**

- Harvest time: this technology is based on late harvest; overripe grapes are harvested (at 23-25 MM<sup>0</sup>). Canes are transected at 'normal' harvest time and depending on weather conditions, grapes are harvested about 15 to 25 days later.
- Grape processing, must clarification, fermentation: overripe grapes are destemmed and crushed and then are filled in fermentation tanks provided with cooling (maybe also heating) appliances, by adding 1 g/q Lallzyme OE extractive enzyme and 50 mg/kg SO<sub>2</sub>. Mash inoculated with selected yeast (UVAFERM SVG) 30g/HL – enhancing fermentation in spite of the high sugar content – with the addition of yeast nutrient UVAVITAL 10+10 g/HL is then fermented to wine at the temperature of 20 to

22°C. Fermentation can be interrupted by cooling after pressing, by adding sulphur and by rough filtering.

#### **4.8.3. New scientific results based on the analyses of the contents of wine:**

1. The application of the DMR-method results in high concentration of Mg and K, and in substantial increase in total polyphenols, leucoantocianin, catechin and shikimic acid.
2. Significant amounts of acylated derivatives can be measured in our Pinot Noir batches, which according to the reference literature are not present in the skins of Pinot Noir berries.
3. Reductive technologies preserve more shikimic acid and quercetin in white varieties.
4. In the case of Pinot Noir the shikimic acid concentration increases as maceration progresses.
5. According to measurements carried out in the project the serotonin content of Pinot Blanc is two or three times higher than that of the other two Pinot varieties.

## 5. CONCLUSIONS AND RECOMMENDATIONS

### **Proposal to prepare regulations of origin protection and technological regulations, to synthesize results:**

The results of my research were utilized already during the research when the regulations governing the protection of origin were modified due to the wine reform in the EU and product descriptions had to be prepared in 2011. Due to the tightening of the rules whereby the European Commission expected to receive unambiguous, clearcut product descriptions from its member states, and their respective wine districts and wine regions, based on our research we prepared the product descriptions listed hereunder. The professional management board of the Badacsony Wine District and the Balaton Wine Region (I am also a member of) developed the current product descriptions taking into account these guidelines. Synthesizing innovative technology and product development set as an objective in the introduction of my thesis took body in the form of descriptions about grape growing and wine making technologies developed and further refined on the basis of the results of the research carried out related to the present thesis as follows:

1. Crisp, fresh, fragrant (Pinot Grigio type) Szürkebarát varietal wine (OFJ/ Protected Geographical Indication)
2. Full-bodied Szürkebarát, typical terroir wine with high alcohol content (OEM/ Protected Designation of origin)
3. Premium quality Szürkebarát with high residual sugar content made by applying the DMR technology (OEM, or OEM prémium / Protected Designation of Origin or premium PDO)
4. Premium quality Pinot Noir with high residual sugar content made by applying the DMR technology (OEM / Protected Designation of Origin)
5. Young, fresh, savoury Pinot Noir rosé wine (made by cold maceration) (OFJ/ Protected Geographical Indication)

### **Proposals for further research work to be carried out**

The quality of the wines produced with the DMR technology was beyond all expectations. Since the current research did not include longer aging experiments in different containers (stainless steel containers, barriques, casks, bottles) for this technology nor did it deal with other varieties, I suggest to focus on these aspects of the treatment in the framework of future research activity.

## 6. PUBLICATIONS RELATED TO THE THEME OF THE THESIS

### Journal Articles with Impact Factor

JAHNKE G. - MÁJER J. - VARGA P. - **SZŐKE B.** (2011): Analysis of Clones of Pinots Grown in Hungary by SSR Markers. *Scientia Horticulturae* (129): 32-37. IF (2009): 1,197

P. VARGA – J. MÁJER – G. GYÖRFFYNÉ JAHNKE - CS. NÉMETH – **B. SZŐKE** – K. SÁRDI – Z. VARGA – L. KOCSIS – B. SALAMON (2012): **Adaptive nutrien supply and soil cultivation methods int he upper zone of hillside vineyards.** *Communications in Soil Science and Plant Analysis*, 43:1-1, 334-340. p. (IF:0,432)

### Journal Articles with No Impact Factor

**SZŐKE B.** - MÁJER J. – FARKAS J. – KÁLLAY M. - GYÖRFFYNÉ JAHNKE G. - VARGA P. (2009): A borok magnézium tartalmát befolyásoló tényezők. *Kertgazdaság* 2009. 41. évf. (3); 36 - 41. p.

**SZŐKE B.** – KÁLLAY M. – MÁJER J. – GYÖRFFYNÉ JAHNKE G. (2010): Borkészítési és borérlelési, valamint szőlőtermesztési technológiák hatása a Pinot fajtakör borainak finomösszetételére és érzékszervi értékére. *Élelmiszer Tudomány Technológia* LXIV. Évfolyam 2010. 1. különszám 1-2. p.

### Conference Papers in English

JAHNKE G. - MÁJER J. - **SZŐKE B.** (2009): Analysis of Pinot Varieties by Microsatellite Markers. Cost 858 Viticulture, final meeting. Book of abstracts 79. p.

JAHNKE G. -MÁJER J. - **SZŐKE B.** (2010): Analysis of Pinot varieties by microsatellite markers. 10th International Conference on Grapevine Breeding and Genetics. Abstracts. 147. p.

### Conference Papers in Hungarian

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