Publishable summary

***Project title*:** PreserveWine, "*Non-thermal process to replace use of sulphites and other chemical preservatives in European wines to meet new European Directive*"

***Grant Agreement** No:* 262507 (FP7-SME-2010-1)
Duration: 01/12/2010 – 15/01/2013
Project Website: www.preservewine.eu

Executive summary

PreserveWine is a partnership of European SMEs that has identified a promising non-thermal process to achieve biological stabilization of wines while avoiding the use of chemical preservatives and keeping their high quality. Pressure Change Technology (PCT) is a low cost process with minimum energy use that has potential with further development and validation to be of significant commercial benefit to wine producers by providing them an alternative to reduce the use of sulphur dioxide in the winemaking process.

PCT is a novel non-thermal technique that involves charging a liquid product with pressure and an inert gas and then rapidly releasing the pressure. The sudden pressure release causes microbial cell walls to rupture, inactivating microorganisms. This process has been demonstrated on a small scale batch unit and in a semi-continuous process for fruit juices. Current development within the PreserveWine project involves its scientific validation with wines and its scale-up into a continuous in-line pre-industrial demonstration unit.

During this project, knowledge of PCT treatment applied to wine treatment and dependencies of the process parameters on wine quality was extended. PCT was more effective inactivating bacteria than yeast at batch level at room temprature and using N_2 at 500 bars (up to 4 log reduction for acetic acid bateria). Therefore, process optimisation is focusing on yeast reduction (*Sacharomyces cerevisae)* in continuous operation. Within first studies, it could be concluded that a low-dose combination of SO_2 and PCT can maximize yeast reduction and avoid its further growth during storage of bottled wine. The novel PreserveWine system significantly reduced the amount of oxygen in white wine, thus providing protection against oxidation directly after treatment and during long-term storage in bottles. Further positive effects included the protection of red wine from colour changes (e.g. intensity of red colour) and the maintenance of physicochemical and sensory quality of tested wines.

The outcome of the PreserveWine project is the successful development and validation of a 120 L/h continuous PCT system to stabilize wine and wine must using state of the art components to enable a rapid and homogenous entrainment of gas at a working pressure of 500 bar. For the continuous PCT system was set-up, a PLC software was developed and suitable sensors were built-in to enable on-line monitoring of parameters during wine treatment. Operation and software manuals were developed and training sessions of partners involved in the experimental

validation were conducted in Germany and France. Furthermore, continuous PCT system operation was demonstrated to all project partners in Bordeaux, France.

A major achievement is that besides keeping key physical-chemical characteristics in wine, the continuous system successfully maintained volatile compounds (e.g. alcohols). A neutral effect of PCT on the overall aroma of the treated wines can be therefore assumed.

1. Project context and objectives

Wine is susceptible to spoilage due to microbial growth and oxidation. Yeast can grow during wine aging and storage and ferment small amounts of residual sugars, leading to turbidity, off-flavours and CO_2 production. In addition, lactic acid bacteria can induce the malolactic fermentation (MLF), which can be beneficial in some cases and undesirable in others. Wine is also susceptible to oxidation, resulting in browning, loss of fruity aroma and aldehydic odours. Current accepted best practice since the 18th century to preserve wine (even organic wines) is through the addition of sulphite in the form of sulphur dioxide (SO_2) E220 as antimicrobial and antioxidant agent. However, current EC regulations are demanding a significant reduction in the use of sulphur dioxide in wines due to health concerns.

PreserveWine is a partnership of European SMEs that has identified a promising non-thermal process to achieve biological stabilization of wines while avoiding the use of chemical preservatives and keeping their high quality. Pressure Change Technology (PCT) is a low cost process with minimum energy use that has potential with further development and validation to be of significant commercial benefit to wine producers by providing them an alternative to reduce the use of sulphur dioxide in the winemaking process.

PCT is a novel non-thermal technique that involves charging a liquid product with pressure and an inert gas and then rapidly releasing the pressure. The sudden pressure release causes microbial cell walls to rupture, inactivating microorganisms. This process has been demonstrated on a small scale batch unit and in a semi-continuous process for fruit juices. Current development within the PreserveWine project involves its scientific validation with wines and its scale-up into a continuous in-line pre-industrial demonstration unit.

1.1. Overall objectives

The aims of this project are:

1. To gain scientific knowledge on the physics of PCT wine treatment and dependencies of the process parameters (e.g. retention time, pressure level, and gas dissolution level) on wine quality, in terms of microbial stability and prevention of oxidation.

2. To define the optimum PCT process to enable significant reduction of spoilage microorganisms (lactic bacteria and yeasts) and to prevent wine oxidation (discoloration and off-flavours) in test red wines and white wines (sweet), at defined processing stages, e.g. during storage in tanks, barrels or bottles.

3. To validate the microbiological quality of the wine, as compared to the conventionally produced wines and in compliance with HACCP & GMP requirements.

4. To compare the organoleptic quality (aroma and taste) of the wines subjected to the PCT process by a trained taste panel

5. Pilot scale demonstration of the PCT system capable of being integrated into a commercial winemaking process line, at flexible design for optional application at various processing stages, with a throughput of 120 L/h

6. Provide data to scale up to industrial capacity of 1.2 m^3/h at energy costs of 40% to comparable thermal processes.

1.2. Work package objectives

According to Annex I, the following objectives had to be fulfilled by month 24:

WP1: PCT wine parameters in laboratory batch scale

General Objectives: To gain scientific knowledge on the physics of PCT for optional use in various wine treatment stages and dependencies of the process parameters (e.g. retention time, pressure level, gas mix, gas dissolution level) on wine quality, in terms of microbial stability and prevention of oxidation.

WP2: PCT Pump

General objectives :

1) Develop and design a pressure system.
2) Develop a continuous working pump unit and reversible turbine with a pressure release component to enable the required rapid pressure drop.
3) Combine and couple the pumping unit with a turbine system for direct energy transmission as a first pressure level, for maximised energy efficiency.

WP3: Continuous PCT process in lab scale

General objectives:

1) Ensure microbial control in wines within a timescale (less than 20 seconds) that is viable for commercial applications in a continuous process.
2) Develop, validate and optimise a continuous gas injection, hold and recovery process;
3) Identify the minimum pressure level required to dissolve gas in product to enable required uniform pressure application to minimise energy usage in gas compression;
4) provide an optimum continuous sequence of retention time and pressures.

WP4: Build prototype unit

General objectives:

To up-scale PCT from a lab process to a continuous working prototype unit with process control to enable industrialisation post project. Ensure that process meets all requirements of hygienic design (including capability for CIP). Ensure that the process can be further scaled up during post project industrialisation phase.

WP5: Analytic & validation

General objectives:

To demonstrate and validate the system's performance and its suitability for use in winemaking (effective reduction of sulphites and other chemical preservatives), economic and environmental

impact, (including energy use), when compared with State-of-the-Art technologies, with equivalent throughput.

WP6: Exploitation and Dissemination

General objectives:

1) Create a Consortium Agreement that handles all background intellectual property issues and ensures that all foreground intellectual property belongs only to the SMEs Participants
2) Identify, assess and, where appropriate, protect all the project results
3) Develop an Exploitation Strategy which will become a firm Business Plan including routes to market for all project results

2. Description of work performed and main results

During the PreserveWine project, knowledge of PCT treatment applied to wine treatment and dependencies of the process parameters on wine quality was extended. A batch reactor provided by Edecto GmbH was modified at Fraunhofer IGB to collect first evidences of wine quality after PCT treatment. These modifications were required to improve usability, transportability and security for the operator. The construction, security and operability of this equipment were certified by the German Technical Inspection Association (TÜV – Technischer Überwachungs-Verein).

Figure 1: Modified PCT batch system

Technology validation at batch level was conducted with different wine types (red and white wines), different type of gases (Nitrogen and Argon), different process conditions (pressure, temperature and retention time) and different microorganisms. PCT treatment significantly reduced microbial load and oxidation potential. PCT was more effective inactivating bacteria than yeast at batch level at room temprature and using N_2 at 500 bars (up to 4 log reduction for acetic acid bateria). Therefore, process optimisation is focusing on yeast reduction (*Sacharomyces cerevisae)* in continuous operation. Within first studies, it could be concluded that a low-dose combination of SO_2 and PCT can maximize yeast reduction and avoid its further growth during storage of bottled wine.

The novel PreserveWine system significantly reduced the amount of oxygen in white wine, thus providing protection against oxidation directly after treatment and during long-term storage in bottles. Further positive effects included the protection of red wine from colour changes (e.g. intensity of red colour) and the maintenance of physicochemical and sensory quality of tested wines. Accordingly, the colour parameter (a*) (Lab color system) used as an indicator of the red color intensity was not affected. By contrast, even small amounts SO_2 treatment largely influenced this wine property.

Finally, the influence of various process parameters, such as gas type and retention time on process efficiency was verified in red and white wines. It was confirmed that process efficiency is mostly influenced by type of gas and pressure level.

The PreserveWine Project successfully developed and validated a 120 L/h continuous PCT system to stabilize wine and wine must using state of the art components to enable a rapid and homogenous entrainment of gas at a working pressure of 500 bar. A gear pump system for low-viscous liquids was designed, built and tested but state of the art technology revealed larger advantages due to performance, market availability and price.

According to a management decision, only one continuous PCT system was built. Due to its complexity, the continuous PCT prototype is a simplified version of the originally planned lab set-up. As stated by Tenute dei Vallarino and Château Guiraud wineries, a prototype with 2 L/min is enough for the proof of principle of the PCT process. Therefore, PCT unit with 20L/min was outlined but not constructed. This decision was communicated to Scientific Officer and accepted.

Development of continuous PCT system included full safety and risk assessments to obtain a certificate of conformity, which was provided by a German technical auditor (TÜV). This included all documentation about high pressure parts and compilation of certificates and pressure tests. Security elements were installed along the system to ensure operation safety, such as security valves, burst discs and emergency stops. The maximum pressure allowed in the system is 525 bar and all the components were selected to achieve minimum 600 bar.

During this project, the continuous PCT system was set-up and built in a modular manner to allow flexibility and performance verification of modules. A PLC software was developed for the continuous system operation and suitable sensors were built-in to enable on-line monitoring of critical variables like pressure, temperature, flow rate and gas dissolution during wine treatment. Operation and software manuals were developed. These included operating and cleaning instructions, maintenance information, and high pressure tests.

Training sessions of partners involved in the experimental validation were conducted in Germany and France. The PCT prototype was delivered to France to project partner Adera on October 2012 for final system validation with wine. Furthermore, continuous PCT system operation was demonstrated to all project partners in Bordeaux, France during the final project meeting.

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Mitglied von TÜV CERT

TÜV SÜD Industrie Service

ZERTIFIKAT
(Konformitätsbescheinigung)
Certificate of conformity

EG-Einzelprüfung (Modul G) nach Richtlinie 97/23/EG
EC unit verification (Module G) according to Directive 97/23/EC

Zertifikat-Nr.: Z-IS-DD1-STG/12/09/100072603-001
Certificate No.:

Name und Anschrift des Herstellers: Frauenhofer Institut für Grenzfläche- und Bioverfahrenstechnik, Nobelstr.12, 70569 Stuttgart
Name and postal address of manufacturer:

Hiermit wird bescheinigt, dass die Ergebnisse der an der unten genannten Baugruppe vorgenommenen Prüfungen die Anforderungen der Richtlinie 97/23/EG erfüllen. Die Baugruppe ist mit unserer Kennnummer gemäß dem abgebildeten CE-Kennzeichen gekennzeichnet:
We hereby certify that the results of the examinations of the assembly meet the requirements of the Directive 97/23/EC. The assembly carries our identification number to the CE-mark as illustrated:

CE 0036

Prüfbericht Nr.: P-IS-DD1-STG/12/09/100072603-001
Test report No.:

Geltungsbereich: PreserveWine Demo unit F.Nr. 002
Scope of examination:

Fertigungsstätte: Frauenhofer Institut für Grenzfläche- und Bioverfahrenstechnik, Nobelstr.12, 70569 Stuttgart
Manufacturing plant:

TÜV SÜD Industrie Service GmbH
Zertifizierungsstelle für Druckgeräte

Filderstadt, 28.09.2012
(Ort, Datum)
(Place, date)

(Reinhold Nüssle)
Benannte Stelle, Kennnummer 0036
Notified Body, Number

Bitte beachten Sie die Hinweise auf der zweiten Seite.
Please note the remarks on the second page.

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Tel.: (08 21) 59 04-1 95, Fax: (08 21) 59 04-1 96, www.tuev-sued.de
Mitglied der CONFÉDÉRATION EUROPÉEN D'ORGANISMES DE CONTRÔLE

Figure 2: Certificate of conformity of continuous PCT system

A major achievement of the technology developed is that besides keeping key physical-chemical characteristics in wine, the continuous PCT system successfully maintained volatile compounds (e.g. alcohols). A neutral effect of PCT on the overall aroma of the treated wines can be therefore assumed.

A HACCP analysis and risk assessment was performed. Because its implementation is not mandatory, wineries involved did not have a running HACCP system. The document generated proposes a HACCP system in wineries based on the OIV recommendation, which could be implemented when working with PCT technology.

Finally, a LiquiSonic® sensor to monitor on-line gas concentration, and therefore liquid/gas mixing properties, was up-scaled to 500 bar and effectively tested for various gas and process parameters at batch level. This monitoring system will be installed in the continuous system to enhance process control during further post-project activities.

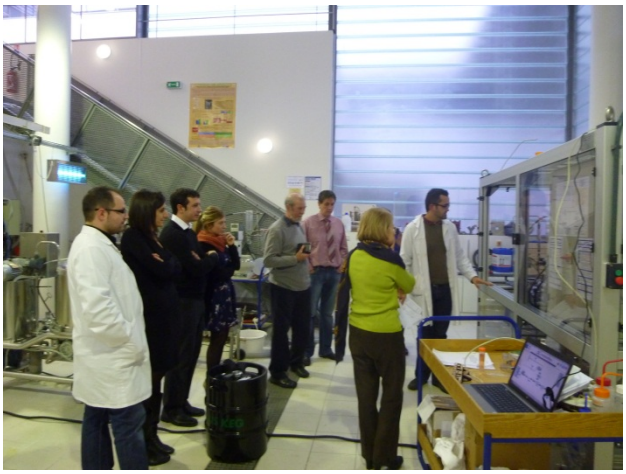

Figure 3: Continuous PCT system installed in Bordeaux, France (left) Demonstration trials during project meeting (right)

3. Socio-economic impact

Europe is the world's leading wine producer; with more than 1.5 million holdings and 1.5 million full-time employees, over 95% working for SMEs. EU27 produces 175million hl p.a., 65% world production, 57% of consumption and 70% of exports. However it is a sector under threat by exports from "New World" wines. Over the last ten years, wine imports to the EU have grown by 10 percent per annum.

According to the **Comité Européen des Entreprises Vins (CEEV)**, the main objective of the wine CMO (Reg. 479/2008) is *"to increase the competitiveness of EU wines, by providing EU oenologist with the largest possible choice of oenological practices so that they can adapt their wines to changing consumers' demands. Sulphites are included in the positive list of allergenic substances to be labelled (annex III of Directive 2000/13). Therefore, the reduction of the SO_2 average dose without undermining the wine quality is an overall objective for the EU wines".* Accordingly, PCT is a technology that has the potential to provide significant benefits when compared with existing techniques; especially in providing consumers the perception of a healthy, preservative-free product.

Within this project, benefits of PCT have been demonstrated. These cover not only the maintenance of physical-chemical and organoleptic quality (color and taste) but also the conservation of oxygen-sensitive components while reducing the use of chemical preservatives (SO2) and enhancing health benefits of wine. The latter will help wine makers to align to current European regulations that have dramatically reduced the minimum levels of application of sulphur dioxide in wines due to the health concerns.

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