

THERMAL TREATMENT OF WINE IN PLATE HEAT EXCHANGERS

TERMIČKA OBRADA VINA U PLOČASTIM IZMJENJIVAČIMA TOPLINE

KOJIC, Nebojsa; ERGOVIC RAVANCIC, Maja & BAJT MANCE, Ivana

Abstract: *The aim of this paper was to show a plate heat exchanger during heat transfer. A good example of this is the thermal treatment of the wine, process which is applied with the aim of microbiological stabilization of the wine. Thermal processing of the wine can affect on the character of the wine, which depends on the heating time, heating temperature, and the level of sulfur dioxide in the wine. Larger changes can be observed at higher temperatures and longer heat treatment. Also, for appropriately sulfur level in wines, the effect is also achieved at lower temperatures.*

Key words: *plate heat exchanger, wine, heat treatment, temperature*

Sažetak: *Cilj ovoga rada bio je prikazati pločasti izmjenjivač topline prilikom prijenosa topline. Dobar primjer za to je termička obrada vina, postupak primijenjen s ciljem mikrobiološke stabilizacije vina. Termička obrada vina može utjecati na karakter vina, a što ovisi o vremenskom trajanju zagrijavanja, temperature zagrijavanja, te razine sumporovog dioksida u vinu. Veće promjene se mogu zamijetiti pri višim temperaturama i duljoj termičkoj obradi. Također, kod primjereno sumporenih vina, učinak se postiže i kod nižih temperatura.*

Ključne riječi: *pločasti izmjenjivač topline, vino, termička obrada, temperatura*



Authors' data: Nebojša, **Kojić**, dipl. ing., pred, Vupik plus d.o.o., Sajmište 113c, Vukovar, nkojic@ptfos.hr; Maja, **Ergović Ravančić**, doc. dr. sc., v. pred, Veleučilište u Požegi, Vukovarska 17, Požega, mergovic@vup.hr; Ivana, **Bajt Mance**, Veleučilište u Požegi, Vukovarska 17, Požega, ibajtmance@gmail.com

1. Introduction

Achieving biological stability in wine has been a problem for winemakers for centuries. There is a certain number of technologies because of their microbiological stabilization ability and includes thermal (steam and hot water heating, ohmic heating, microwave heating, infrared processing, etc.) and nonthermal technologies (high pressure processing, ultraviolet radiation, irradiation, pulsed electric field, chemical treatments, ultrasound, filtration, high voltage arc discharge, etc.). [1]

Despite their well-known efficacy in killing microorganisms, heat treatments have not as many applications in winemaking as in other food industries [2], because of impact on important quality attributes. [3] Nevertheless, there are numerous wineries that thermal processing wines before bottling.

2. Heat treatment of wine

Thermal processing of wine, primarily refer to pasteurization, a term given to heat process typically in the range of 60 – 80 °C and applied for up to a few minutes, and it used for two purposes. First, is the elimination of a specific pathogen or pathogenic associated with a product. The second reason for pasteurizing a product, is to eliminate a large proportion of potential spoilage organism thus extending its shelf-life. [4, 5]

The percentage of microorganisms killed is dependent on factors such as pasteurization temperature, and duration of heating. The overall objective of pasteurization is to ensure that the quality of the product will remain acceptable after a lengthy storage. [6] *Saccharomyces* and *Zygosaccharomyces* are resistant to thermal processing and are found in some spoiled wines. [7] *Alicyclobacillus* species, an acidophilic and thermophilic spore-forming bacteria, has emerged as an important spoilage microbe, causing a smoky taint and other off-flavors in pasteurized wines. [8, 9]

Recently research showed that *Trigonospis cantarellii*, occurring in wine, water, and cellar air, may also represent a new wine spoilage microorganism. [10] Thanks to the alcohol content and low pH of wine, and considering the thermo-tolerance of typical spoilage microorganisms, a mild heating (temperature around 60 °C for 30 s up to a few minutes) is sufficient to achieve sterility. [11] Due to the risk of recontamination, wine pasteurization is preferably carried out just before bottling. [12]

Wine spoilage can result in haze formation, increases in acetic acid and volatile acidity, increase in viscosity, and appearance of off-odors due to volatile compounds such as ethyl acetate, volatile phenols, and others. [13, 14]

The process of mild pasteurization or thermolysis was conceived so that the wine was heated and immediately afterwards entered so warmly into a clean bottle that came out of the washer. Immediately after filling, the bottle have to be sealed. The wine is

gradually cooled in the bottle and thus another important factor in thermolysis was (duration of heat), achieved. In this way it is achieved that the heat in the wine destroys the microorganisms not only in the wine itself, but also in the pipes through which the wine flows, as well as on the walls of the bottle in which the wine will be filled and on the surface of the stopper. Bottle filling and thermolysis were performed simultaneously, saving labor, energy and material. [15]

According to Terčelj and Adamič [16], a thermolysis temperature of up to 50 °C is not yet effective for preventing yeast propagation in wines that have been treated with small amounts of SO₂. Temperatures of 50 °C and above have proven effective. For wines that were adequately sulfited, the effect was achieved at temperatures at 45 °C. A temperature of 50 °C has proven effective against the development of acetic bacteria. [16]

3. Effects of sulfur dioxide on wine

Preservatives used to store food substances act by inhibiting microbial growth. [17] Preservative may be bactericidal and kill target organisms or bacteriostatic which may prevent their growth and thus improve shelf-life of the product. [8] The use of sulfur dioxide (SO₂) as wine additive is able to ensure both antioxidant protection and microbiological stability. [18] Its antimicrobial properties have been exploited against lactic acid bacteria, acetic acid bacteria, *Brettanomyces spp.*, mycodermic yeasts, and various wine spoilage bacteria. [13, 19]

The microbiological stability of wine is fundamental to preserve its quality. In finished wine, typical targets to prevent microbial spoilage are at least 0.6 mg/L molecular SO₂ for dry wines, and at least 0.8 mg/L molecular SO₂ for sweet wines. [20] The percentage of free SO₂ in molecular form is directly related to the pH of the wine. As the pH decreases (≤ 3.0), less SO₂ must be added to the wine to maintain the proper molecular levels. Wine, which is closer to value pH 4.0, will need much more SO₂ to maintain the proper molecular level. At molecular levels below 0.5 mg/L, SO₂ does not provide sufficient antimicrobial protection to ensure the stability of the wine. [18]

Pasteurization as a mean to prevent spoilage by microbial contamination was almost universally replaced by the addition of sulfites. This addition has the additional advantage of preventing the oxidation of the wine, which the pasteurization does not. [20] Still, wines that are appropriately sulfited and additionally heat treated are not liable to spoilage, which is the primary objective.

4. Plate heat exchanger

The plate heat exchanger used for wine pasteurization procedure is consists of a pack of corrugated metal plates with port holes for the passage of two fluids between

which heat transfer will take place. The plate pack is assembled between a frame plate and a pressure plate and compressed by tightening bolts. The plates are fitted with a gasket which seals the channel and directs the fluids into alternate channels. [21] Figure 1. shows gasketed plate and frame exchanger. [22]

The work of Malletroid et al. [23] used a pasteurization technique over a heat exchanger used without homogenizer to minimize oxidation, operated at 74.4 –76.1 °C. The number of plates are determined by the flow rate, physical properties of the fluids, pressure drop and temperature program. The plate corrugations support the plates against differential pressure.

Also, the corrugation of the plates provides a passage between the plates, supports each plate against the adjacent one and enhances the fluid turbulence, resulting in efficient heat transfer. Corner ports and gaskets are arranged so that the two media flow through alternate channels. [23]

The plates have a chevron pattern for maximum strength at high working pressures. Different chevron designs are available, in order to obtain optimal high heat transfer and low pressure drop. A unique distribution area provides an even flow over the plate surface. The plates are reversible and have parallel flow, which means only one type of plate is needed. [6, 21] Advantages are: compact design, a very large surface area over a small volume which can be modified as per requirement by increasing or decreasing the number of plates and advances in material technology. [24]

The basic principle of heat exchanger is the transfer of heat between two fluids. Two fluids are brought in close contact with each other but are prevented from mixing by a physical barrier. The temperature of the two fluids leads to an equilibrium temperature. The energy from each fluid is exchanged and no extra heat is added or removed. [25]

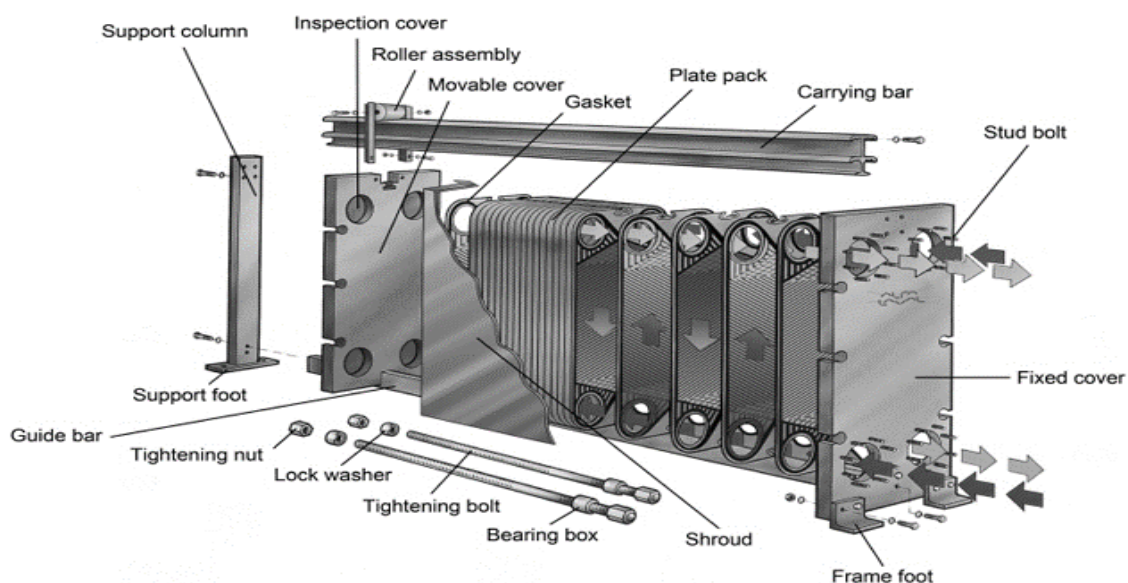


Figure 1. Gasketed plate and frame exchanger [28]

Figure 2. shows schematic of a chevron-type plate. [28] Plate heat exchangers are very efficient and can be easily disassembled for cleaning and sterilization to meet health and sanitation requirements. [21, 26] Modern plate heat exchangers provide higher working temperatures, larger working pressures, higher resistance to chemicals, etc. All liquid contact surfaces are manufactured in stainless steel that eliminates corrosion due to contaminated water. If stainless steel is not suitable other higher grade materials are available, such as titanium. In wine processing pasteurizing is a key element to ensure a safe product suitable for human consumption. [21, 26, 27]

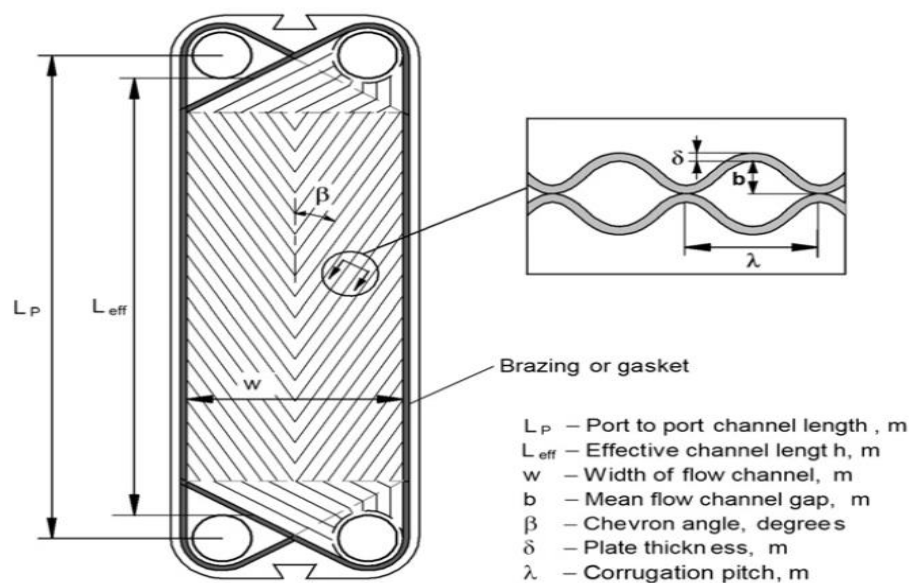


Figure 2. Schematic of a chevron-type plate [28]

5. Conclusion

Heat treatments is well-known in efficacy in killing microorganisms and have an impact on important wine quality attributes. Nevertheless, there are numerous wineries that thermal processing wines before bottling. Thermal processing of wine, primarily refer to pasteurization to eliminate a large proportion of potential spoilage organism thus extending its shelf-life. The percentage of microorganisms killed is dependent on factors such as pasteurization temperature and duration of heating. Some of yeasts are resistant to thermal processing and are found in some spoiled wines.

The use of sulfur dioxide (SO_2) as wine additive is able to ensure both antioxidant protection and microbiological stability. The percentage of free SO_2 in molecular form is directly related to the pH of the wine. As the pH decreases, less SO_2 must be added to the wine to maintain the proper molecular levels. The plate heat exchanger used for wine pasteurization procedure is consists of a pack of corrugated metal plates with port holes for the passage of two fluids between which heat transfer will

take place. The number of plates are determined by the flow rate, physical properties of the fluids, pressure drop and temperature program. The plate corrugations promote fluid turbulence and support the plates against differential pressure, resulting in efficient heat transfer. In thermal processing of wine, heat transfer is a key element to ensure a safe product suitable for human consumption. Plate heat exchangers are very efficient and can be easily disassembled for cleaning and sterilization. If stainless steel is not suitable other higher grade materials are available, such as titanium.

6. Literature

- [1] Lisanti, M. T.; Blaiotta, G.; Nioi, C. & Moio, L. (2019). Alternative Methods to SO₂ for Microbiological Stabilization of Wine. *Comprehensive Reviews in Food Science and Food Safety*, 18, 455-479, 1541-4337.
- [2] Ferreira, M. M. (2011). Yeasts and wine off-flavours: A technological perspective. *Annals of Microbiology*, 61, 1, 95–102, 1590-4261.
- [3] Ling, B.; Tang, J.; Kong, F.; Mitcham, E. J. & Wang, S. (2015). Kinetics of food quality changes during thermal processing: A review. *Food and Bioprocess Technology*, 8, 2, 343–358, 1935-5130.
- [4] Silva, F. V. M.; Gibbs, P. A.; Nuñez, H.; Almonacid, S. & Simpson, R. (2014). Thermal Processes: Pasteurization. In: *Encyclopedia of Food Microbiology*, 2nd edition. Carl, A. Batt; Mary Lou Tortorello, eds., 577–595. Academic Press, 9780123847331, San Diego.
- [5] Wilbey, R. A. (2014). Heat treatment of foods: principles of pasteurization. In: *Encyclopedia of Food Microbiology*, 2nd edition. Carl, A. Batt; Mary Lou Tortorello, eds., 169-174. Academic Press, 9780123847331, San Diego.
- [6] Lauro, E. M. & Fuleki, T. (1987). Development of a mobile juice and wine pasteurizer. *Canadian Agricultural Engineering*, 29, 1, 85-87.
- [7] Silva, F. V. M. & Gibbs, P. A. (2004). Target selection in designing pasteurization processes of shelf-stable high-acid fruit products. *Critical Reviews in Food Science and Nutrition*, 44, 5, 353-360, 1040-8398.
- [8] Chang, S. S. & Kang, D. H. (2004). *Alicyclobacillus* spp. in the fruit juice industry: history, characteristics, and current isolation/detection procedures. *Critical Reviews in Microbiology*, 30, 2, 55-74, 1549-7828.
- [9] Chen, S. Q.; Tang, Q. Y.; Zhang, X. D.; Zhao, G. H.; Hu, X. S.; Liao, X. J.; Chen, F.; Wu, J. H. & Xiang, H. (2006). Isolation and characterization of thermo-acidophilic endospore-forming bacteria from the concentrated apple wine processing environment. *Food Microbiology*, 23, 5, 439-445, 740-020.
- [10] Portugal, C.; Pinto, L.; Ribeiro, M.; Tenorio, C.; Igrejas, G. & Ruiz-Larrea, F. (2015). Potential spoilage yeasts in winery environments: Characterization and proteomic analysis of *Trigonopsis cantarellii*. *International Journal of Food Microbiology*, 210, 113–120, 0168-1605.
- [11] Ribéreau-Gayon, P.; Dubourdieu, D.; Donéche, B. & Lonvaud, A. (2006a). *Handbook of Enology: The Microbiology of Wine and Vinifications (Vol. 2)*, John Wiley & Sons Ltd, 0470010347, Chichester, England.

- [12] Ribéreau-Gayon, P.; Glories, Y.; Maujean, A. & Dubourdieu, D. (2006b). *Handbook of Enology. The chemistry of wine and stabilisation and treatments*, (Vol. 2). John Wiley & Sons Ltd, 9780470010372, Chichester, England.
- [13] Bartowsky, E. J. (2009). Bacterial spoilage of wine and approaches to minimize it. *Letters in Applied Microbiology*, 48, 2, 149–156, 0266-8254.
- [14] Du Toit, M. & Pretorius, I. S. (2000). Microbial spoilage and preservation of wine: Using weapons from nature's own arsenal – A review. *South African Journal of Enology and Viticulture*, 21, 74–96, 2224-7904.
- [15] Žanko, V. (1964). Biološka stabilizacija vina toplinom. *Agronomski glasnik*, 14, 8-9, 62-65, 0002-1954.
- [16] Terčelj, D. & Adamič, J. (1966). Termolizacija vina. *Agronomski glasnik*, 16, 6-7, 447-456, 0002-1954.
- [17] Ihekoronye, A. I. & Ngoddy, P. O. (1985). *Integrated Food Science and Technology for the Tropics*. Macmillan Educational LTD, Cornell University, 121-147, 0333388836, Ithaca, NY.
- [18] Kojić, N. (2019). Djelovanje sumporovog dioksida u vinu. *Glasnik Zaštite Bilja*, 42, 6, 86-92, 2584-3265.
- [19] Oelofse, A.; Pretorius, I. S. & du Toit, M. (2008). Significance of *Brettanomyces* and *Dekkera* during winemaking: A synoptic review. *South African Journal of Enology and Viticulture*, 29, 2, 128–144, 2224-7904.
- [20] Waterhouse, A. L.; Sacks, G. L. & Jeffery, D. W. (2016). *Understanding Wine Chemistry*, 1st edition. John Wiley & Sons, 978-1-118-62780-8, New Jersey, SAD.
- [21] Kakaç, S. & Liu, H. (2002). *Heat Exchangers: Selection, Rating, and Thermal Design* (2nd ed.). Florida, CRC Press, 373-412, 0849309026.
- [22] Jangid, S. (2018). Plate Type Heat Exchanger – A Review Study. *IOSR Journal of Engineering*, 8, 10, 11-18, 2278-8719.
- [23] Malletroit, V.; Guinard, J. X.; Kunkee, R. E. & Lewis, M. J. (1991). Effect of pasteurization on microbiological and sensory quality of white grape juice & wine. *Journal of Food Processing and Preservation*, 15, 1, 19-29, 1745-4549.
- [24] Abu-Khader, M. M. (2012). Plate heat exchangers: Recent advances. *Renewable & Sustainable Energy Reviews*, 16, 4, 1883–1891, 1364-0321.
- [25] Rašković, P.; Anastasovski, A.; Markovska, Lj. & Meško, V. (2010). Process integration in bioprocess industry: waste heat recovery in yeast and ethyl alcohol plant. *Energy*, 35, 2, 704-717, 0360-5442.
- [26] Sundén, B. & Manglik, R. M. (2007). *Plate heat exchangers: Design, applications and performance*. Southampton, WIT Press, 185312737X.
- [27] Palm, B. & Claesson, J. (2006). Plate heat exchangers: Calculation methods for single-and two-phase flow. *Heat Transfer Engineering*, 27, 4, 88-98, 0145-7632.
- [28] Huang, J.; Sheer, T. J. & Bailey-McEwan, M. (2012). Heat transfer and pressure drop in plate heat exchanger refrigerant evaporators. *International Journal of Refrigeration*, 35, 2, 325–335, 0140-7007.



Photo 036. Obuka / Training