

REVIEW PAPER

Processing Innovations and Quality Aspects of Wine-Based Food Products: A Comprehensive Review

Kosaraju Shiva Kumar and Rajadurai Murugan*

Department of Food Technology, Faculty of Life and Allied Health Sciences, M.S. Ramaiah University of Applied Sciences, Mathikere, Bangalore, Karnataka, India

*Corresponding author: rajaduraidpi@gmail.com

Paper No.: 364

Received: 07-05-2026

Revised: 26-05-2026

Accepted: 12-05-2026

ABSTRACT

Food products based on wine have been developed as value-added systems whereby the bioactive properties and sensory properties of wine are integrated into various food matrices. This review is a critical assessment of the processing technologies and quality parameters that affect products like vinegars, reductions, jellies and wine-infused bakery products. Comparisons of thermal treatments (e.g., pasteurization) with non-thermal ones (e.g., membrane filtration and high-pressure processing) are made with regards to how they affect aroma, color, and retention of nutrients. Important physicochemical and sensory properties are addressed in connection with the processing conditions that include temperature, pH, and oxygen presence. The stability of bioactive substances including flavonoids and resveratrol is examined, as well as changes in texture, anthocyanins, phenolics, and volatile chemicals. The determinants of shelf-life, such as microbial and oxidative stability and packaging effects, are also discussed. In general, the processing conditions should be optimized to achieve a balance in quality, stability, and functional characteristics in wine-based food systems.

Keywords: Wine-based food products, winery by-products, non-thermal processing, shelf-life stability

The use of wine as an ingredient in various food systems is on the rise, owing to its special sensory properties and abundance of bioactive compounds. Besides being used as a beverage, wine has also been noted as a natural source of colour, taste and preservation besides being used as a source of valorising winery by-products. As a result of wine production, 20-30% of the mass of grapes is left as pomace (skins, seeds, stems), which used to be a waste in the past (Beres *et al.* 2017). Nevertheless, this by-product is currently considered a rich source of polyphenols, dietary fiber, organic acids, and antioxidant and antimicrobial compounds that can be used in meat, dairy, cereal, and other food products (García-Lomillo and González-Sanjosé, 2017).

Also, other winery residues, including lees, vine

shoots, and grape stalks, have been considered as a source of functional ingredients in food formulations and active packaging systems, which lead to better product stability and long shelf-life (Mendes and Duarte, 2021; Troilo *et al.* 2021; Nardella *et al.* 2022). Meanwhile, the wine as a system is quite complex and sensitive, with factors like exposure to oxygen, temperature, light, and packaging conditions affecting shelf-life. Non-enzymatic oxidation can be caused by excess oxygen and metal ions and discouraged by inadequate oxygen levels, which can result in ageing color and aroma deterioration

How to cite this article: Kumar, K.S. and Murugan, R. (2026). Processing Innovations and Quality Aspects of Wine-Based Food Products: A Comprehensive Review. *Int. J. Food Ferment. Technol.*, 16(01): 307-317.

Source of Support: None; **Conflict of Interest:** None 

(Gutiérrez-Escobar *et al.* 2021; Mercanti *et al.* 2024). Thus, corks, screw caps, or new sustainable materials are essential to control the oxygen transfer and quality of the product (Mercanti *et al.* 2024; Maragou *et al.* 2024).

In addition to direct consumption, wine and wine-based ingredient is being added to formulated foods including marinade, functional beverages and fermented products. An example is red wine-based marinades, which can add antimicrobial and antioxidant properties, increase flavor, but can also alter acidity and color properties (Nardella *et al.* 2022; Latoch *et al.* 2023). On the same note, fruit-based wines made with berries or pomegranate serve as examples of using fermentation to convert perishable raw materials into value added products that are stable and have increased bioactive potential (Bezerra *et al.* 2024).

Although there has been increasing importance on wine-based food products, the majority of the research has been conducted individually on either the processing technologies, compositional or the use of by-products. There is a lack of integrated knowledge about the effects of processing techniques, composition of raw material and storage conditions on quality characteristics and stability in shelf-life. Consequently, this review will critically assess the contribution of processing technologies, physicochemical and sensory parameters, and storage factors to the quality and stability of wine-based food products.

Literature Search Strategy

The review was done by searching and analysing scientific literature systematically in databases such as Scopus, Web of Science and Google Scholar. The selection of relevant studies published between 2010 and 2025 was based on the keywords: wine-based food products, winery by-products, polyphenols, non-thermal processing, and shelf-life stability (Paramasivam *et al.* 2024). Peer-reviewed research articles, review papers, and quality publications were only taken into consideration. The literature gathered was critically reviewed to determine the

most important processing technologies, quality factors, and shelf-life stability factors that relate to wine-based food products.

Typology of Wine-Based Food Products

Pomace, lees, stems, seeds and vine shoots wine and winery by-products are being increasingly employed in the production of liquid, solid and hybrid food products at an industrial level. These applications are expected to increase nutritional value, enhance product stability, and prolong shelf-life, and also aid the principles of a circular economy by reducing agro-industrial waste (García-Lomillo and González-Sanjose, 2017; Ferrer-Gallego and Silva, 2022; Constantin *et al.* 2024). They contain abundant amounts of polyphenols, dietary fiber, and bioactive compounds of antioxidant and antimicrobial activities and this has led to the increasing presence of these materials in food systems.

Liquid Derivatives

1. Direct wine-based liquids

Wines, juices fortified with grape pomace or solid extracts to enrich the level of polyphenols, vitamins, and bioactive compounds such as resveratrol are liquid derivatives (Ferrer-Gallego and Silva, 2022; Fataliyev *et al.* 2024). Besides, alcohol-free and low-alcohol wine products and concentrates are also under consideration as they have potential to become health-oriented drinks, and they still possess functional characteristics (Kubyshevskiy *et al.* 2018). Wine and liquid lees distilled products are also used as food grade alcohol and specialty beverages (Ferrer-Gallego and Silva, 2022).

2. Functional beverages

Functional beverages like juices, soft drinks, and fortified formulations are common examples of using wine by-products as additives to improve the antioxidant properties and nutrition (Ferrer-Gallego and Silva, 2022; Fataliyev *et al.* 2024). Applications include aromatized waters, herbal infusions, and sweetened beverages enriched with wine-derived

compounds to improve flavor, color, and potential health benefits (Tsoupras *et al.* 2023; Constantin *et al.* 2024).

Solid and Semi-Solid Products

1. Bakery and cereal products

One of the most frequent applications of wine by-products is bakery, which includes bread, biscuits, crackers, cakes, muffins and pasta. Incorporation of grape pomace, grape skin, or seed flours has been reported to enhance the dietary fiber content, antioxidant activity, and lipid stability (García-Lomillo and González-Sanjosé, 2017; Ferrer-Gallego and Silva, 2022; Constantin *et al.* 2024). Pomace-enriched extruded products have been shown to contain higher resistant starch levels and phenolic levels, but lack usability due to low sensory acceptability (Cotacallapa-Sucapuca *et al.* 2025).

2. Dairy and frozen products

Fermented dairy products are also used to incorporate wine by-products in yogurt, cheese, and ice cream to improve antioxidant activity, color, and functional properties (Ferrer-Gallego and Silva, 2022; Tsoupras *et al.* 2023; Constantin *et al.* 2024; Fataliyev *et al.* 2025). Regardless of such advantages, their introduction can have an adverse impact on the texture and flavor and it is necessary to optimize formulation and processing conditions.

3. Confectionery and gels

Extracts made using wine are also finding application in confectioneries like jelly candy, where they may provide antioxidant effects and possible functional advantages. Though other studies indicate antidiabetic effects, the findings need to be confirmed with clinical studies to be used widely (Lasik-Kurdyś *et al.* 2025).

4. Hybrid products

Multifunctional products are created by using liquid wine components together with solid by-products in the form of hybrid food systems. The use of

wine lees or pomace in meat and fish products has demonstrated a positive effect on oxidative stability and shelf-life because of their natural antioxidant and antimicrobial properties (García-Lomillo and Gonzalez-Sanjosé, 2017; Troilo *et al.* 2021; Constantin *et al.* 2024). Likewise, technological use (texture, color, stabilization) and health-promoting (enriching with polyphenol and fiber) purposes of pomace are applied in cereal-based extruded products (Almanza-Oliveros *et al.* 2024). In general, the fact that wine and wine by-products are used in various product lines proves the great potential to improve nutritional quality and sustainability. Nevertheless, issues associated with sensory acceptability, formulation stability and optimization of processes are still vital determinants that affect their large-scale use (Table 1).

Raw Material Selection and Characterization

The kind of wine type and grape variety is crucial in defining quality, stability and functionality of wine-based food products. The grape variety, geographical origin, and processing conditions are all factors that have a significant impact on the composition of organic acids, sugars, minerals and polyphenols, which, in turn, affect processing behavior, sensory attributes and potential health benefits.

1. Red vs. White Wine Varieties

There are considerable compositional variations in the red and white wines, and these differences directly affect the suitability of the wines in different food applications. Rich in polyphenolic compounds, including anthocyanins, tannins, catechins, and resveratrol, red wines are usually rich in these substances, which provide color intensity, astringency, and antioxidant activity, as well as potential health benefits (Gutiérrez-Escobar *et al.* 2021; Nemzer *et al.* 2021; Onache *et al.* 2023). Moreover, the red wines tend to have more pH values and a higher concentration of some minerals (e.g., B, Ba, Cr, Cu, Mn, Sr, Zn), in part, because of malolactic fermentation, in which malic acid is converted into lactic acid (Gajek *et al.* 2021).

Table 1: Representative categories and examples of wine-based food products

Product group	Examples of wine-based products	References
Liquid derivatives	Functional wines, juices, fortified drinks, alcohol-free wine	Ferrer-Gallego and Silva (2022); Fataliyev <i>et al.</i> (2024); Kubyshkin <i>et al.</i> (2018)
Solid/semi-solid	Bread, biscuits, pasta, yogurt, cheese, ice cream, snacks, candies	Constantin <i>et al.</i> (2024); Ferrer-Gallego and Silva (2022); García-Lomillo and González-Sanjosé (2017)
Hybrid products	Meat and fish products, fortified cereals, extruded snacks	Constantin <i>et al.</i> (2024); García-Lomillo and González-Sanjosé (2017); Troilo <i>et al.</i> (2021)

White wines, in their turn, have lower amounts of total polyphenols, but more tartaric and malic acids, which leads to higher levels of titratable acidity and fresher taste profile (Gajek *et al.* 2021; Jakabová *et al.* 2021). They contain phenolic compounds that are dominated by phenolic acids, flavonols, flavan-3-ols instead of anthocyanins (Mosele *et al.* 2023; Onache *et al.* 2023). White wines therefore are better in applications involving a lighter color and a greater acidity whereas red wines are better in applications involving high antioxidant and color stability.

2. Chemical Composition

Wine is a compound system that is made up of volatile and non-volatile compounds that characterize its functional and technological characteristics. The predominant non-volatile is a water-ethanol mixture with alcohol content of 11.5 to 13.8% (v/v), which varies based on the grape variety and the production conditions (Jakabová *et al.* 2021; Nemzer *et al.* 2021). Glucose and fructose: Sugars affect the sweetness as well as the fermentation kinetics and the final product properties (Han *et al.* 2022; Budziak-Wieczorek *et al.* 2023).

Tartaric, malic, lactic, acetic, and succinic acids are organic acids that are very important in defining the acidity, flavor balance, and microbial stability (Fermo *et al.* 2021; Jakabova *et al.* 2021). Potassium, calcium, magnesium, and iron among other minerals make wine products stable, clear, and authentic (Fermo *et al.* 2021; Gajek *et al.* 2021).

Phenolic compounds are one of the most significant functional ingredients of wine especially in food. The

anthocyanins, flavan-3-ols, procyanidins, flavonols, phenolic acids, and stilbestes (resveratrol) are the most common flavonoids and non-flavonoids found in red wines, respectively, which cause antioxidant activity and color stability, as well as astringency (Gutiérrez-Escobar *et al.* 2021). White wines also have a considerable amount of phenolic acids and flavonols that help to achieve oxidative stability and sensory quality, despite having lower total phenolics (Jakabová *et al.* 2021; Nemzer *et al.* 2021; Onache *et al.* 2023). In general, the content of polyphenols is one of the main factors that determine the antioxidant activity, color stability and functional potential, and thus polyphenol content is an important consideration in the selection of wine raw materials in the development of food products (Table 2).

Processing Technologies

In order to satisfy customer demands for minimally processed and low-additive meals, wine-based food products are based on advanced processing technologies that offer microbiological safety, physicochemical stability, and an appealing sensory quality. To preserve product quality and extend shelf-life, both thermal and non-thermal processing technologies and unique dealcoholisation techniques are crucial. (Li and Padilla-Zakour, 2021; Chiozzi *et al.* 2022; Al-Sharify *et al.* 2025;).

1. Thermal Processing

The most common method of inactivating spoilage microorganisms and enzymes in wine-based products involves the use of thermal treatments like pasteurization and sterilization. Such approaches

Table 2: Chemical composition of wine and their functional roles

Component group	Major constituents	Functional roles	References
Major non-volatile components	Water, ethanol, glycerol, nitrogen compounds	Provide basic matrix, influence body, viscosity, and stability	Han <i>et al.</i> (2022); Nemzer <i>et al.</i> (2021)
Sugars	Glucose, fructose	Affect sweetness, fermentation, and product characteristics	Budziak-Wieczorek <i>et al.</i> (2023); Han <i>et al.</i> (2022)
Organic acids	Tartaric, malic, lactic, acetic, succinic	Control acidity, flavor, and microbial stability	Fermo <i>et al.</i> (2021); Jakabová <i>et al.</i> (2021)
Minerals	Potassium, calcium, magnesium, iron	Influence stability, clarity, and authenticity	Gajek <i>et al.</i> (2021)
Phenolic compounds	Flavonoids and non-flavonoids	Antioxidant activity, color, astringency	Gutiérrez-Escobar <i>et al.</i> (2021); Nemzer <i>et al.</i> (2021)
Volatile compounds	Esters, alcohols, aldehydes, ketones, terpenes	Contribute to aroma and flavor	García-Viñola <i>et al.</i> (2024)
Functional bioactives	Polyphenols (resveratrol, flavonoids)	Antioxidant, cardioprotective, anti-inflammatory effects	Nemzer <i>et al.</i> (2021)

work well and are economically viable but can cause degradation of heat-sensitive substances. Indicatively, pasteurization (e.g., 70°C 10 min) has been found to enhance microbial safety and shelf-life, but has been reported to decrease antioxidant activity during storage (Nguyen, 2023). In a similar vein, lower heat treatments (e.g., 63°C 3 min) can confer a few months of refrigerated stability, but can lead to a decrease in color intensity, volatile aroma compounds, and overall sensory quality versus non-thermal options (Li and Padilla-Zakour, 2021). In general, thermal processing is a trusted, inexpensive method; nonetheless, it has such shortcomings as the destruction of nutrients and loss of fresh sensory properties, and some changes in the formulation might be necessary to preserve the quality of the product.

2. Non-Thermal Processing

A new technology, non-thermal processes, has been discovered to be an efficient substitute to standard heat treatments, providing microbial safety and improved preservation of sensory and nutritional properties with reduced use of chemical preservatives (Silva and Van Wyk, 2021; Kumar *et al.* 2023; Peric *et al.* 2024). The High-Pressure Processing (400-600 Megapascal) is effective in inactivating microorganisms and preserving phenolic compounds

and antioxidant activity, thereby increasing the shelf-life. Pulsed Electric Field can also be used to break the membranes of microbial cells by using pulsed electric fields with little effect on sensory quality, as well as to increase the extraction of phenolic compounds. Ultrasound (US) assists in the inactivation of microbes as well as extracting compounds, though the efficacy of the process relies on the conditions. Other novel technologies such as ultraviolet (UV) treatment, cold plasma, and high-pressure homogenization demonstrate encouraging outcomes, but there are still issues of scalability, cost, and industrial applicability (Li and Padilla-Zakour, 2021; Al-Sharify *et al.* 2025).

3. Dealcoholisation techniques

One of the technologies used in the manufacture of low- and alcohol-free wine-based products is dealcoholization, which allows preserving sensory and functional characteristics and reducing the level of ethanol. The methods are generally used post-fermentation, but can be incorporated in various stages of processing (Sam *et al.* 2021; Kumar *et al.* 2024).

4. Thermal distillation methods

Vacuum distillation and spinning cone column (SCC) are other forms of thermal methods that utilise low pressure to reduce the boiling point of ethanol

enabling easy extraction of alcohol. However, these techniques are fast and efficient but can lead to extensive losses of volatile aroma compounds and can also change the color and flavor balance (Sam *et al.* 2021; Akhtar *et al.* 2025; Italiano *et al.* 2025).

5. Membrane-based methods

Selective removal of ethanol at relatively low temperatures is achieved through membrane technologies, such as reverse osmosis (RO), nanofiltration (NF), osmotic distillation, and pervaporation. Such approaches are superior in preserving non-volatile compounds, as well as maintaining aroma and sensory properties compared to thermal methods; (Sam *et al.* 2021; Akhtar *et al.* 2025; Kumar *et al.* 2025). However, the efficiency of the process is highly dependent on operational parameters such as pressure, membrane characteristics, and temperature.

Processing conditions significantly influence the sensory and quality attributes of the final product. While membrane-based techniques help retain volatile aroma compounds better than thermal treatments, improper optimization may still lead to partial loss of fruity and floral notes, reduction in flavor intensity, and changes in mouthfeel due to alteration in ethanol–water balance. Additionally, dealcoholisation can affect physicochemical properties, including decreased alcohol content, reduced acidity, slight changes in pH, and possible modifications in color and clarity. These changes may impact overall consumer acceptability if not carefully controlled.

In contrast, thermal processing often results in greater degradation of heat-sensitive compounds, leading to loss of fresh aroma, cooked flavors, browning reactions, and reduced nutritional quality, whereas non-thermal methods better preserve bioactive compounds, antioxidants, and natural sensory profiles. Nevertheless, both non-thermal and membrane-based methods require precise control to avoid quality deterioration.

In sum, non-thermal and membrane-based methods

exhibit better retention of bioactive compounds and sensory characteristics than conventional thermal processing. Their large-scale industrial application, however, is often limited by higher operational costs and scalability challenges. Therefore, integrating mild thermal treatments with emerging non-thermal technologies could provide a balanced approach to ensuring product safety, maintaining quality, and achieving economic feasibility. The comparative effect of different processing technologies on the retention of key quality attributes is illustrated in Fig. 1.

Quality Parameters

Interactions of volatile and non-volatile compounds determine the quality of wine-based food products and affect aroma, color, and mouthfeel and ultimately consumer perception and acceptability (Khalafyan *et al.* 2023; Welke *et al.* 2024).

1. Aroma profile

The volatile compounds that control the aroma consist of esters, alcohols, acids, aldehydes, and terpenes, which give the aroma fruit and flower smell. Esters, in particular, are one of the most valuable aroma markers (Cao *et al.* 2022; Wen *et al.* 2023). The perception of aroma can be affected by the interactions between compounds, and ethanol can increase odor intensity and some volatiles can affect the perceived sweetness. Aroma profiles are characterized using analytical methods like GC-MS and sensory techniques like quantitative descriptive analysis (QDA).

2. Color stability

Other pigments that affect color include anthocyanins that change in processing and storage. Anthocyanins in red wines are polymeric pigments, which stabilize and change color to a brick-red with time passing (Sun *et al.* 2022). Color stability is improved with co-pigmentation. The color change is usually analyzed with the CIELab system (L, a, b) that quantifies the oxidation and the degradation of pigments (Cao *et al.* 2022).

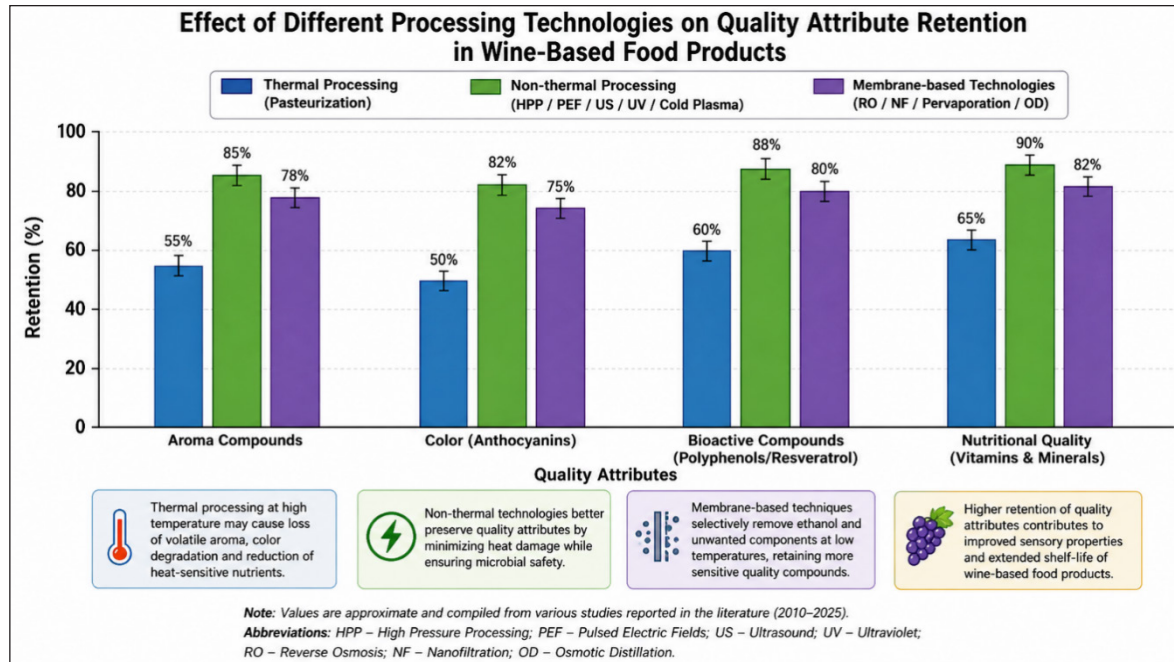


Fig. 1: Effect of thermal, non-thermal, and membrane-based processing technologies on retention of aroma compounds, color, bioactive compounds, and nutritional quality in wine-based food products

3. Texture and rheology

Ethanol, glycerol, polysaccharides, sugars, acids, and pH affect mouthfeel properties including viscosity, body and astringency. Astringency is due to the reactions between the tannin and the salivary proteins (Paissoni *et al.* 2023). Flow and lubrication properties are measured through rheological and tribological measurements, whereas sensory evaluation is necessary to assess the overall acceptability. In general, quality properties are highly sensitive to composition and processing parameters and need to be carefully optimized in order to preserve sensory and functional activity.

Key Bioactive Compounds

Wine has a wide variety of bioactive molecules which are categorized as flavonoids and non-flavonoids. The antioxidant activity, color, and astringency are also offered by flavonoids, such as flavan-3-ols (catechin, epicatechin), flavonols (quercetin, myricetin), anthocyanins, and tannins (Buljeta *et al.* 2023; Rayess *et al.* 2024). Other non-flavonoid compounds like phenolic acids (gallic, caffeic, p -coumaric acids),

stilbestrols (resveratrol) have been linked with different biological activities. Other compounds such as melatonin and hydroxytyrosol have also been discovered and could have antioxidant, cardio protective and neuro protective properties, but there is a lack of clinical evidence. The by-products of wineries, including pomace, winery-skin, winery-seeds, and winery-lees, are rich sources of these compounds and could be used in the development of functional foods (Ferrer-Gallego and Silva, 2022; Constantin *et al.* 2024).

Reported Health Benefits

Wine-derived polyphenols have been linked to cardiovascular protection, such as antioxidant, anti-inflammatory, vasodilatory effects, better lipid profiles, and LDL oxidation (Fernandes *et al.* 2017; Buljeta *et al.* 2023; Rayess *et al.* 2024). They can also help to improve metabolic well-being, such as increased insulin sensitivity and decreased obesity and diabetes risk, especially when made out of by-product extracts (Ferrer-Gallego and Silva, 2022; Constantin *et al.* 2024). Moreover, antioxidant and

anti-inflammatory activities have been associated with possible neuroprotective and anti-aging effects, but there is little evidence in humans. Resveratrol and quercetin are polyphenols that have shown anti-cancer and anti-inflammatory effects *in vitro* and animal studies. However, concerns over bioavailability, dosage, and individual variation have raised concerns on the need to conduct additional controlled clinical trials in order to confirm their health benefits in the long term. In general, although wine-derived bioactive compounds have a great potential in terms of their functionality, their impact on human health is dependent on the dosage, the form of consumption, and the individual differences, and the existing evidence should be viewed with caution.

Shelf-Life and Stability

Microbial activity, oxidative reactions, and packaging conditions affect the shelf-life of wine-based food products. Primary (sealed) and secondary (post-opening) shelf-life should be taken into account since they may differ greatly (Bianchi *et al.* 2023; Mercanti *et al.* 2024).

1. Microbial stability

Microbial spoilage in wine-based products is mainly caused by yeasts (e.g., *Brettanomyces*, *Candida*), lactic acid bacteria, and acetic acid bacteria, leading to off-flavors, turbidity, and the formation of undesirable compounds such as biogenic amines (Toit and Pretorius, 2019). The traditional preservation techniques are refrigeration, acidification, sulphur dioxide (SO₂) and stringent hygienic conditions. Even though SO₂ is still among the most useful preservatives because of its antimicrobial and antioxidant properties, other methods, including lysozyme, ascorbic acid, high-pressure processing, pulsed electric field, UV treatment, and bio protection are being actively investigated to decrease the use of chemicals (Lisanti *et al.* 2019).

2. Oxidative stability

One of the primary causes of short shelf-life is

oxidation that is mainly due to non-enzymatic reactions with oxygen and metal ions. The effects of these reactions are browning, aroma loss, and polyphenols degradation (Bai *et al.* 2024; Mercanti *et al.* 2024). Restricted oxygen contact (micro-oxygenation) can increase the complexity of flavors, but too much oxygen will hasten quality loss. Oxidative degradation is further promoted by other environmental factors including temperature, light, and UV exposure. Natural antioxidants, such as polyphenols and SO₂, are redox buffers that contribute to maintaining the stability of the products (Lisanti *et al.* 2019; Mercanti *et al.* 2024).

3. Packaging Influence

The packaging is important to preserve the quality of the wine by controlling the oxygen flow and resisting environmental influences. The type of closure has a considerable impact on oxygen permeability, where natural cork enables moderate oxygen entry, screw caps offer near hermetic protection, and artificial closures tend to allow increased oxygen entry (Mercanti *et al.* 2024). Glass containers tend to be more effective to preserve aroma and color, but alternative storage options like bag-in-box can be beneficial in certain storage conditions. Oxygen levels in the headspace, temperature and exposure to light also affect shelf-life. New methods of packaging, such as oxygen scavengers, modified atmosphere packaging, and active antimicrobial or antioxidant films have a great potential in extending shelf-life and enhancing sustainability (Mercanti *et al.* 2024; Masamba, 2024). In general, shelf-life stability in wine-based products can rely on an interactive control of microbial activity, oxidation, and packaging systems, which demonstrates the necessity of integrated preservation measures.

DISCUSSION

Wine-based food product development depends on processing methods, raw material composition, and quality outcomes. Thermal processing ensures safety but can reduce aroma, color, and bioactive compounds, whereas non-thermal techniques better

preserve these attributes but face cost limitations. Wine type influences product characteristics due to variations in polyphenols, acidity, and color stability.

Shelf-life is affected by microbial activity, oxidation, and packaging, with oxygen control playing a key role. Compliance with safety regulations for sulfites, residual ethanol, and contaminants is essential. Consumer acceptance remains critical, as preferences impact the success of innovative products. Overall, effective product development requires optimizing processing, ensuring safety, and maintaining desirable sensory attributes.

CONCLUSION

Wine-based food products are a new and promising industry that combines processing technologies with quality, safety, and functionality factors. Thermal and non-thermal processing methods are important factors that affect retention of aroma, color and bioactive compounds, which subsequently affect the product acceptability and stability. The use of wine and wine by-products increase nutritional quality by providing polyphenols and other useful ingredients, as well as by promoting the sustainable management of winery waste. Microbial control, oxidative reactions, and packaging strategies control shelf-life stability, and thus the optimization of preservation systems. Irrespective of the problems associated with the changes in senses and processing constraints, the recent developments in processing technologies and clean-label strategies present considerable opportunities to innovate. In general, food products based on wine have great potentials of application in functional and sustainable food systems that add value in the food industry.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy,

integrity, and originality of the work presented, and no AI tool was listed as an author.

REFERENCES

- Akhtar, W., Ceci, A.T., Longo, E., Marconi, M.A., Lonardi, F. and Boselli, E. 2025. Dealcoholized wine: Techniques, sensory impacts, stability, and perspectives of a growing industry. *Compr. Rev. Food Sci. Food Saf.*, **24**.
- Almanza-Oliveros, A., Bautista-Hernández, I., Castro-López, C., Aguilar-Zárate, P., Meza-Carranco, Z. and Rojas, R. 2024. Grape pomace: Advances in its bioactivity, health benefits, and food applications. *Foods*, **13**: 580.
- Al-Sharif, Z.T., Al-Najjar, S.Z., Anumudu, C.K., Hart, A., Miri, T. and Onyeaka, H. 2025. Non-thermal technologies in food processing: Implications for food quality and rheology. *Appl. Sci.*, **15**: 3049.
- Bai, X., Chen, X., Li, X., Tan, F., Sam, F.E. and Tao, Y. 2024. Wine polyphenol oxidation mechanism and its effects on wine quality: A review. *Compr. Rev. Food Sci. Food Saf.*, **23**.
- Beres, C., Costa, G.N.S., Cabezudo, I., da Silva-James, N.K., Teles, A.S.C. and Cruz, A.P.G. 2017. Towards integral utilization of grape pomace from wine-making process: A review. *Waste Management*, **68**: 581–594.
- Bezerra, M., Ribeiro, M., Cosme, F. and Nunes, F.M. 2024. Overview of the distinctive characteristics of berry wines and spirits. *Compr. Rev. Food Sci. Food Saf.*, **23**.
- Bianchi, A., Taglieri, I., Macaluso, M., Sanmartin, C., Zinnai, A. and Venturi, F. 2023. Effect of different packaging strategies on the secondary shelf-life of red wine. *Foods*, **12**: 2719.
- Budziak-Wieczorek, I., Maśań, V., Rząd, K., Gładyszewska, B., Karcz, D. and Burg, P. 2023. Evaluation of wine quality using physico-chemical and spectroscopic techniques. *Molecules*, **28**: 6326.
- Buljeta, I., Pichler, A., Šimunović, J. and Kopjar, M. 2023. Beneficial effects of red wine polyphenols on human health: A comprehensive review. *Curr. Issues Mol. Biol.*, **45**: 782–798.
- Cao, W., Shu, N., Wen, J., Yang, Y., Jin, Y. and Lu, W. 2022. Characterization of aroma volatile compounds in grape wines. *Foods*, **11**: 2767.
- Chiozzi, V., Agriopoulou, S. and Varzakas, T. 2022. Advances and comparison of thermal and non-thermal technologies in food processing. *Appl. Sci.*, **12**: 2202.
- Constantin, O.E., Stoica, F., Rațu, R.N., Stănciuc, N., Bahrim, G.E. and Râpeanu, G. 2024. Bioactive components and applications of winery by-products. *Antioxidants*, **13**: 100.
- Cotacallapa-Sucapuca, M., Berrios, J. de J., Pan, J., Alves, P., Arribas, C. and Pedrosa, M.M. 2025. Functional extruded products using winemaking by-products. *Processes*, **13**: 1635.

- du Toit, M. and Pretorius, I.S. 2019. Microbial spoilage and preservation of wine: A review. *S. Afr. J. Enol. Vitic.*, **21**.
- el Rayess, Y., Nehme, N., Azzi-Achkouty, S. and Julien, S.G. 2024. Wine phenolic compounds: Chemistry and health benefits. *Antioxidants*, **13**: 1312.
- Fataliyev, H., Gadimova, N., Huseynova, S., Isgandarova, S. and Heydarov, E. 2024. Enrichment of functional drinks using grape pomace extracts. *East. Eur. J. Enterp. Technol.*, **3**: 37–45.
- Fermo, P., Comite, V., Sredojević, M., Ćirić, I. and Gašić, U. 2021. Elemental analysis and phenolic profiles of wines. *Foods*, **10**: 158.
- Fernández-Mar, M.I., Mateos, R., García-Parrilla, M.C., Puertas, B. and Cantos-Villar, E. 2012. Bioactive compounds in wine. *Food Chem.*, **130**: 797–813.
- Ferrer-Gallego, R. and Silva, P. 2022. Wine industry by-products and their applications. *Antioxidants*, **11**: 2025.
- Gajek, M., Pawlaczyk, A. and Szykowska-Jozwik, M.I. 2021. Multi-elemental analysis of wine samples. *Molecules*, **26**: 214.
- García-Lomillo, J. and González-SanJosé, M.L. 2017. Applications of wine pomace in food industry. *Compr. Rev. Food Sci. Food Saf.*, **16**: 3–22.
- Gutiérrez-Escobar, R., Aliaño-González, M.J. and Cantos-Villar, E. 2021. Wine polyphenol content and quality. *Molecules*, **26**: 718.
- Han, S., Yang, J., Choi, K., Kim, J. and Adhikari, K. 2022. Chemical analysis of white wines and consumer acceptability. *Foods*, **11**: 603.
- Italiano, L., Kumar, Y., Schmitt, M. and Christmann, M. 2025. Comparison of dealcoholised wine production methods. *OENO One*, **59**.
- Jakabová, S., Fikselová, M., Mendelová, A., Ševčík, M. and Jakab, I. 2021. Chemical composition of white wines. *Appl. Sci.*, **11**: 11059.
- Khalafyan, A., Temerdashev, Z., Abakumov, A. and Yakuba, Y. 2023. Analysis of volatile compounds in wine. *Heliyon*, **9**: e12814.
- Kubyshekin, A., Ogai, Y., Fomochkina, I. and Chernousova, I. 2018. Polyphenols of red grape wines. In: *Polyphenols. InTech*.
- Kumar, Y., Khalangre, A., Suhag, R. and Cassano, A. 2025. Applications of membrane processes in wine industry. *Membranes*, **15**: 140.
- Laguna, L., Álvarez, M.D., Simone, E., Moreno-Arribas, M.V. and Bartolomé, B. 2019. Wine texture perception and instrumental analysis. *Foods*, **8**: 190.
- Lasik-Kurdyś, M., Gumienna, M., Krzywonos, M. and Mohd Adzahan, N. 2026. Alcohol-free wine-based jelly candies with grape pomace. *LWT*, **239**: 118952.
- Latoch, A., Czarniecka-Skubina, E. and Moczowska-Wyrwisz, M. 2023. Natural marinades for shelf-life improvement. *Foods*, **12**: 3638.
- Li, Y. and Padilla-Zakour, O.I. 2021. High pressure processing of grape puree. *Foods*, **10**: 2608.
- Lisanti, M.T., Blaiotta, G., Nioi, C. and Moio, L. 2019. Alternatives to SO₂ in wine stabilization. *Compr. Rev. Food Sci. Food Saf.*, **18**: 455–479.
- Maragou, N.C., Tzachristas, A. and Tsochatzis, E.D. 2024. Chemical migration in wine contact materials. *Appl. Sci.*, **14**: 6507.
- Marcotrigiano, V., Cinquetti, S., Flamini, R., de Rosso, M. and Ferraro, L. 2020. Safety in wine production. *Int. J. Environ. Res. Public Health*, **17**: 3283.
- Masamba, M. 2024. Impact of packaging materials on food shelf-life. *J. Food Sci.*, **5**: 15–28.
- Mendes, E. and Duarte, N. 2021. Mid-infrared spectroscopy in food analysis. *Foods*, **10**: 477.
- Mercanti, N., Macaluso, M., Pieracci, Y., Brazzarola, F. and Palla, F. 2024. Enhancing wine shelf-life. *Heliyon*, **10**: e35688.
- Mosele, J., da Costa, B.S., Bobadilla, S. and Motilva, M.J. 2023. Phenolic composition of wine by-products. *J. Agric. Food Chem.*, **71**: 18746–18757.
- Nardella, S., Conte, A. and del Nobile, M.A. 2022. Recycling fruit by-products to prolong shelf-life. *Foods*, **11**: 665.
- Nemzer, B., Kalita, D., Yashin, A.Y. and Yashin, Y.I. 2021. Polyphenolic compounds of red wines. *Beverages*, **8**: 1.
- Nguyen, G.T.H. 2023. Effects of pasteurization on beetroot wine quality. *Sci. Technol. Dev. J.*
- Onache, P.A., Florea, A., Geana, E.I. and Ciucure, C.T. 2023. Bioactive phenolic compounds in wines. *Appl. Sci.*, **13**: 5722.
- Paramasivam A., Murugan R., Jeraud M., Dakkumadugula A., Periyasamy R. and Arjunan S. 2024. Additives in Processed Foods as a Potential Source of Endocrine-Disrupting Chemicals: A Review. *J. Xenobiot.*, **14**: 1697–1710.
- Paissoni, M.A., Motta, G., Giacosa, S., Rolle, L. and Gerbi, V. 2023. Mouthfeel subqualities in wines. *Compr. Rev. Food Sci. Food Saf.*, **22**: 3328–3365.
- Perić, K., Tomašević, M., Ćurko, N. and Brnčić, M. 2024. Non-thermal technologies in wine-making. *Appl. Sci.*, **14**: 6612.
- Sam, F.E., Ma, T.Z., Salifu, R., Wang, J. and Jiang, Y.M. 2021. Dealcoholization techniques in wine. *Foods*, **10**: 2498.

- Silva, F.V.M. and van Wyk, S. 2021. Non-thermal technologies as alternatives to SO₂. *Foods*, **10**: 2175.
- Sun, X., Shokri, S., Gao, B., Xu, Z. and Li, B. 2022. Co-pigments effect on blueberry wine fermentation. *LWT*, **156**: 113070.
- Troilo, M., Difonzo, G., Paradiso, V.M., Summo, C. and Caponio, F. 2021. Bioactive compounds from wine by-products. *Foods*, **10**: 342.
- Tsoupras, A., Ni, V.L.J., O'Mahony, É. and Karali, M. 2023. Bio-functional compounds in wine. *Fermentation*, **9**: 838.
- Welke, J.E., Hernandez, K.C., Lago, L.O., Silveira, R.D. and Marques, A.T.B. 2024. Flavoromic analysis of wines. *J. Chromatogr. A*, **1734**: 465264.
- Wen, J., Wang, Y., Cao, W., He, Y., Sun, Y. and Yuan, P. 2023. Evaluation of *Actinidia arguta* wines. *Foods*, **12**: 3345.

