D6: Low and/or non-alcoholic wine (NLAW[1])

1) **An exploration of the reasons for the growth of this category**

Cultivated wine consumption becomes intertwined with social entertainment for some people—a pleasant evening spent with a good dinner, engaging conversations, the combined joy of sharpening the mind, and the pleasure of taste.
However, the number of individuals and groups *seeking alternative ways to enjoy their time* is growing significantly, no longer negligibly. *Personal reasons* such as *health preservation*, a sense of *"equality" at various social events* and adherence to certain *societal expectations* and rules contribute to the demand for low-alcohol or alcohol-free wines.

From a business perspective, using up every year's existing *surplus resulting from overproduction* in the wine industry turning them into a “new” product, or the *avoidance of specific countries' additional taxes* on alcoholic beverages motivates the growth of this category, on the other hand, it could be a response to the gradual increase in temperatures and dryness in recent decades, aiming to *mitigate the higher alcohol content in wines*.

The emerging *new generation* (Generation Z) is incredibly *mindful of their health*, aiming to avoid the "intoxicating" effects of alcohol while *equally desiring to enjoy their days*, evenings, and social events. Analysis indicates (IWSR, 2023) that these consumers almost equally prefer non-alcoholic beverages in general, with wine being one of the many options. Additionally, various *social norms*, expectations, rules, and *religious requirements* outright prohibit alcohol consumption for many people. *Muslims* can find Halal-certified wine, where alcohol removal happens religiously, containing 0% abv alcohol. Situations coming from a *certain life stage* such as pregnancy or breastfeeding, *health situations* such as alcohol intolerance, completely abstinent *work environments*, *staying fresh* for the next big-day, and *driving* a vehicle also exclude the consumption of alcoholic beverages. W*ithout the harmful effects of alcohol consumption*, the world could become a more peaceful place: *decreasing the number of criminal activities* or *preventing severe injuries* caused by intoxication as *high-fatality road accidents*, and *domestic violence*.

In recent years, these social groups have increasingly turned to low-alcohol or alcohol-free drinks and wines, showing an average annual growth of around 4% in quantity and a 4-5% increase in sales value from 2020 to 2023 [Source: IWSR.com]. Through *global social media coverage*—partly thanks to the overwhelming COVID pandemic, which significantly increased the demand for healthier products—the *trendy*, alcohol-free, *sporty lifestyle*, the carefree pairing of everyday food and wine (none of the regrets), the expression of novel, *liberal femininity*, and the enjoyment of festivals and *social gatherings without intoxication* are spreading rapidly.

The medical field is at the forefront of this subject. The fact is that alcohol was responsible almost for 300,000 deaths within the EU in 2020. Although in the early 1990s scientific evidence proved that drinking one to three glasses of wine per day can help reduce the risk of a cardiovascular attack, today’s research proves that non-alcoholic wine may offer *memory-enhancing benefits*, *decrease cholesterol-level and blood pressure*, and *lower the risk of stroke and certain cancers*. People want to say *goodbye to morning nausea*, headaches, brain fog, and next-day anxiety. They want to wake up every morning *without hangover*.

[1] When presenting this paper, I categorized the production of alcohol-free (<0.5%), low-alcohol (0.5-1.2%) and reduced-alcohol (<6,5%) wines under the term "no/low alcohol wines" (NLAW).

The trend has become global: be sober, not boring! The world is frolicking in the “sober curious” movement. In Europe, the United Kingdom and Germany, France leads in the consumption of alcohol-free wines, while in America, the USA and Canada prefer low-alcohol wines. In Asia, Japan leads in consuming reduced-alcohol and alcohol-free wines [Source: IWSR].

Regarding their relationship to alcohol, consumers form 4 distinct categories: “Abstainers” who don’t drink alcohol at all, “Blenders” who drink either full-strength alcohol drinks or NLAW on the same occasion, the first-time “Triallers” and “Substituters” who drink full-strength or NLAW depending on the occasion (NoLo_lecture, 2023).

Consumers are not only avoiding alcohol but also *emphasizing reduced calorie intake* and the consumption of low-sugar "organic" drinks. Analysis shows that a non-alcoholic wine contains three to six times fewer calories than its alcoholic counterpart, due to their production process.

All ranges of wine styles are available in the non/low alcoholic category nowadays: red, white, rose, as well sparkling. They can be dry or sweet, depending on the original wine or the process of the dealcoholisaton and the after-treatment.

Producers in this segment - whose numbers are constantly growing -, are doing everything to meet these demands with ever-improving sensory quality. According to IWSR's forecast, there will be a steadily growing demand for alcohol-free products in the coming years. And the market size is not negligible with an estimated 10bn USD in 2021 coming up from USD 7.8bn in 2018 and with a growing potential of a +8% compound annual growth rate (CAGR) between 2021 and 2025 [IWSR].

Dealcoholisation technology has become more sophisticated in recent years, employing new techniques and technologies to preserve colours, aromas, and mouthfulness, from standard quality base wines to mid-range products, all the way to premium and super-premium wines and champagnes. This way, every social stratum can find the *attractive and valued price category* that suits them.

WHO and governments also take their part in encouraging people: in some countries, they insist on *increasing the availability of non-alcoholic wine*. Increasing *excise duty* applied to alcoholic beverages, *lowering the price segment* to be accessible to a broader audience, enforcing bans or *restrictions on alcohol advertising*, and promotion.

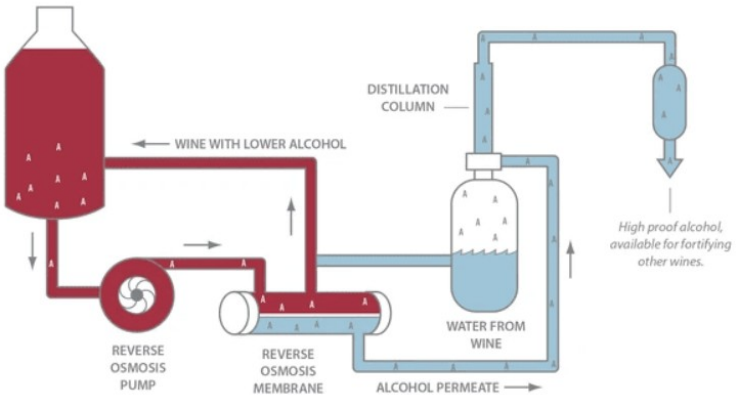
This market segment, in terms of volume and revenue, is no longer just a "fancy" trend; these products will diversify the product range for a long time, encouraging producers to create new non-alcoholic, fruity, and floral-scented wines.

2) Evaluation of the different post-fermentation options for reducing or removing alcohol and how these impact final style, quality and price

The reduction of alcohol content in wines after fermentation can be achieved through two fundamental methods: membrane-based and heat-based processes, with various techniques (Sam, 2021).

1) Reverse osmosis (RO)

In the RO (reverse osmosis) process a hydrophilic semi-permeable membrane with pores of 0.1 to 0.5 nanometers aids in separating water and alcohol from other substances under pressure[2], while the remaining aromatic and flavour components are reintroduced into the initial tank (Pilipovik M.V., 2005). The process is repeated several times to achieve the desired alcohol reduction, leading to significant volume loss.



1. Figure: Schematic figure of the RO procedure (B&STech, 2023)

Due to the low operational temperatures (5–10°C), there is relatively little negative impact on flavours with no or minimal loss in the original aroma volatile compounds. (BevZero, 2023).

In terms of mouthfeel, the tightening, dry sensation in the mouth increases with the decrease in alcohol content, driven by a concentrated phenolic content or the diminishing of the masking effect of alcohol (Lisanti, 2013). The treated wine experiences a noticeable increase in sugar content and total acidity, accompanied by a decrease in the pH value, volatile acidity and SO_2 level of the product. There is no noticeable dulling in the colour of the final NLAW product, however, it is crucial to avoid exposure to oxygen during the process, and the adjustment of the original wine's sulphur content plays an important role in the quality of the NLAW.

The process is considered "clean" as the recovered ethanol can be reused after distillation, but substantial water usage is a drawback.

2) Nanofiltration (NF)

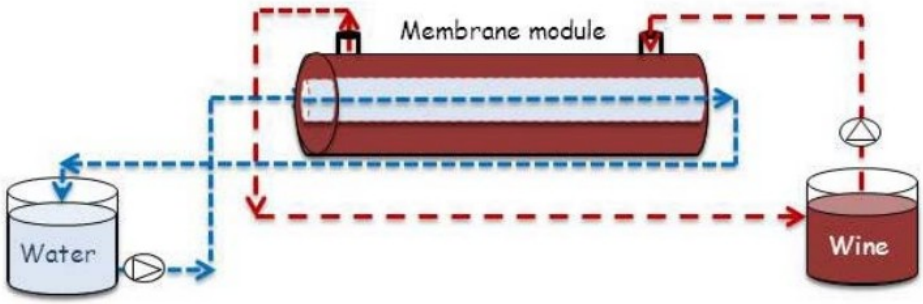
Nanofiltration (NF), another membrane-based process, uses semi-permeable membranes with larger pores (1-10 nanometers) and operates more efficiently than RO due to the lower trans-membrane pressure, the shorter process duration (Ivic, 2021).

NF shows low ethanol rejection, leading to a 4-5% reduction in alcohol content with high aroma retention. Similar to RO, total acidity, total extract, and sugar concentration increase. (Catarino, 2011). NF can be combined with other techniques for enhanced sensory results.

[2] Typically used pressure for RO is 4MPa.

3) Osmotic distillation (OD)

Osmotic distillation is an isothermal membrane distillation, where wine and water circulate in counter-flow on opposite sides of a hydrophobic membrane (Tengzhen, 2022), and the ethanol vapour diffuses through the membrane pores and condensates into the stripping water solution, applying both the principles of osmosis and distillation.



2. Figure: Scheme of OD semi-pilot plant equipped with membrane module (Russo P.; 2019)

It operates at low temperatures with only a slight loss of aromas and flavours, resulting in a wine with increased astringency and acidity but lower odour, sweetness, fruitiness, and body (Sam, 2021). OD is suitable for approximately 5-6% reduction without changing the colour.

Compared to RO, it has lower alcohol selectivity, requires longer processing time, and is often used following an RO process for better sensory quality (Russo P., 2019).

4) Pervaporation (PV)

Pervaporation (PV) is a concentration-driven, membrane-based, low-energy consumption process based on the partial evaporation of liquid mixtures with similar boiling points (Tengzhen, 2022). It effectively reduces alcohol content while preserving aromas, with minimal losses. Its limited popularity is due to specialized membranes and low permeation rates at low temperatures. PV is often employed after nanofiltration to selectively extract additional aromas and enhance the flavour quality.

Membrane-based methods offer higher concentrations of bioactive compounds than the initial wine, improving nutritional value and quality, although the original chemical composition has a significant influence on the resulting NLAW product. The high pressure an low temperature influence the quality and the quantity of the change in the phenolic and flavonoid content, the retention of anthocyanins and the antioxidant activities after dealcoholisation in a positive way.

However, they can be carried out with relatively low operational costs after the initial investment, there are economic considerations due to alcohol dilution, requiring additional steps for separation to sell the alcohol on the secondary market. Modern technologies combine membrane techniques for better results, such as simultaneous application of NF and PV or RO and OD (Tengzhen, 2022).

Overall, while RO is primarily used for a 1-2% reduction in alcohol content (Pickering, July 2000), it may result in up to a 30% loss due to the gradual reduction and potential loss of aromatic compounds from multiple procedures. These membrane-based methods are fundamentally suitable for low-alcohol wine production, with each technique having its advantages and drawbacks.

For the production of alcohol-free wines, the following heat-related treatments are widely applied: vacuum distillation and spinning cone column. The main difference is that with these procedures the alcohol level of the treated wine can be decreased even almost to 0% v/v.

5) Vacuum distillation (VD)

Vacuum distillation, an evolved method for lowering wine alcohol levels, employs a vacuum system to extract ethanol at low temperatures (~35°C). The process involves evaporation, distillation, and condensation under vacuum conditions (Sam, 2021).

The vacuum facilitates the extraction of ultralight volatile aroma components, followed by the evaporation of alcohol in the wine. The separated aromas are reintroduced at the end, ensuring minimal losses (B&STech, 2023).



3. Figure: A vacuum distillation machine (NIX, 2023)

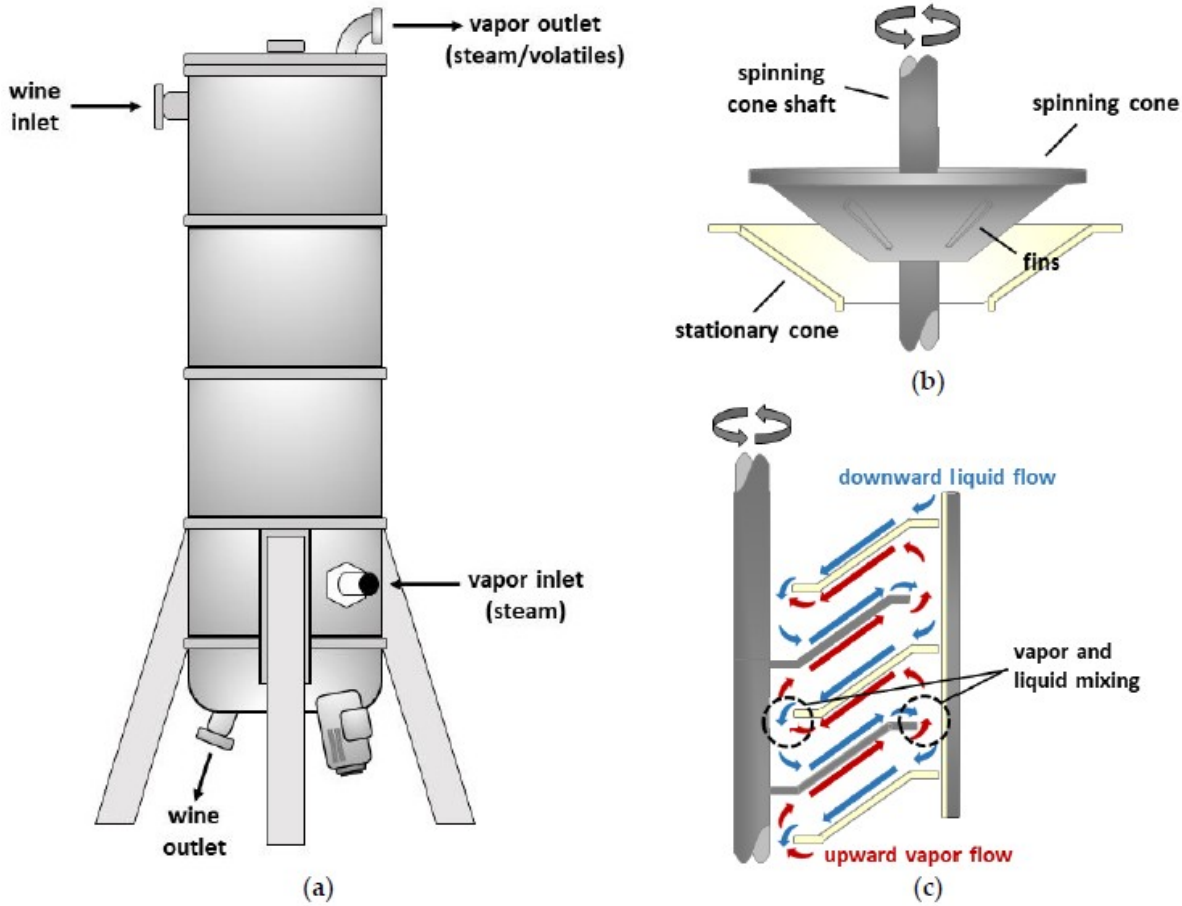
This single-step procedure concentrates flavonoids, organic acids, and anthocyanins in the dealcoholized liquid. Higher alcohols and ethyl esters decrease significantly (Petrozziello, 2019). The resulting NLAW has minimal losses thanks to aroma recycling.

The method is environmentally friendly, with low water use, energy requirements, and maintenance costs, making it a sustainable option for alcohol reduction in wine production.

6) Thermal vacuum distillation with Spinning Cone Column (SCC)

The Spinning Cone Column (SCC) process utilizes centrifugal force and vacuum simultaneously to separate volatile substances, aromas, and alcohol from wine. The SCC, a vertical stainless-steel column with rotating and fixed cones, efficiently vaporizes wine in super-fine layers. In the first step, the most volatile aromas are separated and captured, constituting 1-3% of the quantity. The second step

selects alcohol, which is then condensed for reuse (ConeTech, 2010). T volatile aromas separated in the first round are reintroduced into the dealcoholized wine.
State-of-the-art equipment combines aroma separation, alcohol selection, and alcohol rectification in a single process, at extremely low temperatures.



4. Figure: Schematic diagram of a) a spinning cone column distillation system; b) a set of rotating and stationary cones; c) the downward flow of liquid and upward flow of vapour within the spinning cone column during operation (Puglisi, 2022)

Sensory and laboratory analyses indicate minimal to negligible changes in the quality, aroma, and mouthfeel of the resulting non-alcoholic wine when optimal SCC parameters are applied. Aroma concentration may even improve as a result of ethanol separation (Belisario-Sánchez, 2011). Up to 100% of aroma components can be recovered for white and rosé wines, slightly less for red wines. While some changes in sweetness, fruity intensity, and total acidity occur, they are deemed acceptable for consumers (Alises, 2023).

The technical advantages of SCC include high efficiency, low energy consumption, fully automated operation, minimal loss, and short residence time in the heat-treated environment. Alcohol can be reduced from 15% to <0.5% – <0.02% ABV in a single pass.

However, the technology's widespread adoption is hindered by high initial and operating costs, with reimbursement occurring after producing approximately 1 million litres of alcohol-free wine, the rectified alcohol has a high market value which strongly influences the viability and economy of the equipment.

The vacuum distillation process based on SCC technology is considered the most promising in the market. Large-scale producers develop cutting-edge technologies and make them available to smaller producers through leasing or paid services.

The interplay of various aromatic components contributes to the distinctive characteristics of wine (Goldner, 2009). **The dealcoholisation process** transforms the flavour profile of alcohol-free wine, impacting the perception of volatile taste and aroma compounds (Schmidtke LM, 2012 Jan). While the presence of alcohol content may diminish the perception of fruity aromas, as alcohol content decreases, both aromatic quality (volatile composition) and taste tend to worsen (Tengzhen, 2022). Due to alcohol removal, total acidity and tannins become concentrated, with a decrease in the product's pH, resulting in a sharper sensation in terms of perception. High-end solutions aim to preserve sensory properties such as body, fullness, viscosity, phenolic characteristics, and the balance of residual sugar and acids.

Non-alcoholic wines come in various styles, and technology seeks to produce products that closely match the sensory characteristics of the original wine. In principle quality of low-alcohol products lies in the timing of the fully ripe harvest and the creation of a base wine with a maximum flavour profile, still in some cases, final products are blended with full-strength wine or grape must concentrate to restore the original aroma balance and mouthfeel before bottling.

3) A personal opinion on the future of the category

The anticipated growth of this market (GMI, 2023 Dec) seems rightfully inevitable.
In the following, I will elaborate on how, to what extent, and in what manner I believe *the various growth drivers contribute to these changes*, also providing *recommendations for further increasing the consumption* of NLAW products.

Societal Drivers

- **Health and lifestyle**

Although numerous analyses and studies confirm the health benefits of moderate wine consumption, believing in the phenomenon known as the 'French Paradox', I agree with the general medical recommendation that suggests excluding alcoholic beverages from daily consumption routines. A shift towards NLAWs is noted, with 41% of consumers in the USA choosing them for health and wellness reasons (NielsenIQ, 2022). Evidently, this is the segment where the biggest advantage comes from.

- *Medical recommendations should actively promote alcohol-free alternatives in interventions such as rehabilitation programs.*

- **Religion**

I anticipate that the group of consumers choosing NLAW products for religious reasons will not significantly increase, given the challenge of justifying the consumption of once-alcoholic products.

- **Socialization**

I see the greatest driving force in this segment. Those who choose a kind of alcohol-free and exhilaration-free subset of entertainment consciously embrace the role of ambassadors for a 'healthy' worldview, promoting the success of NLAW products as a social event.

- *Bartenders should take on a more active role switching consumers opting for a non-alcoholic drink to alcohol-free wine.*

- *Inclusion of an alcohol-free "mocktail" corner at corporate events can validate the enjoyment value of non-alcoholic beverages.*

- **Characteristics of Participants**

Consumer characteristics reveal a preference for incorporating NLAWs into daily life rather than complete replacement. The majority falls into the 'Substituters' category, forming the largest group and driving future consumption. The number of alcohol purchases will decrease proportionally with the number of “Triallers” and First Buyers (Anderson P, 2022 Sep 13)

- *Should the product no longer disappoint upon the first try, an increasing number of tryers are expected to hopefully join the 'Substituter' category.*

Economic, Market Drivers at the Consumer Level

- **Price**

Consumer preferences, adoption and popularity of NLAWs are mainly impacted by the pricing strategy.

- **Marketing**

Surveys show that consumers are attracted to prominent "ZERO" or "0.0" labels displayed on bottles and labels.

- *Non-alcoholic wine conferences and exhibitions, with dedicated booths for demonstrations can significantly contribute to increasing the popularity of the product.*

- **Social Media**

Social networking, social media trends, TV shows or “hype-driven” events can mobilize millions from one day to another, having foundation for these "innovative" initiatives.

- *Some top influencers with millions of followers enable positive (or even negative) experiences to spread like wildfire across platforms.*

- **Availability**

While its market already shows significant prevalence and acceptance by projecting a healthier and better worldview to people, the supply and accessibility have not yet fully revealed the latent demand. In many smaller countries, such as Hungary, the offering of non-alcoholic beverages, including wines, does not currently stand out.

Legislation
Given that the sale of alcoholic products and institutions dealing with the harmful effects of alcohol are simultaneously under government control in many countries, the legislation aims to encourage the spread of NLAW products manifested through the tax system, pricing policies, and product labelling (relevant values, alcohol content, carbohydrate content, added ingredients).

- *Wine bottle labelling displays deterrent images and text, similar to cigarette packaging, potentially would divert more people towards non-alcoholic beverages.*

Producers
Producers and distilleries continually strive to improve quality. The major players in the market, large-scale investors with increasingly sophisticated technical equipment carry the growth potential.

- *Taking joint innovative steps by sharing technological advancements and resources for maintaining and expanding the consumer base.*

Quality

- **Taste**

There is no question that aroma and taste are amongst the most crucial quality factors influencing the acceptance of wine by consumers. Based on my personal experience, the taste of NLAW products varies between "off-putting" and truly enjoyable.

- **Style**

Although every style is already present in the market today, in my opinion, the taste of sparkling wine, which is closest to the original with the role of carbon dioxide playing a "veiling" role, highlighting the original aromas. Producers face the most challenging task with red wines, where, despite using the most modern processes, it is difficult to reintegrate a sensory quality similar to the original by breaking down the matrix-like aroma structure that has formed during longer ageing processes.

- **Shelf life**

According to consumer habits, the goal of this product type is not preservation but immediate, event-oriented, prompt consumption, preferably as frequently and as widely as possible, replacing as many alcoholic beverages as possible!

I see a bright future for this market, with trends indicating a broader adaption, especially among those contemplating a significant reduction in alcohol intake (KAM, 2023). And I hope that there will be times when stereotypes around non-alcoholic wines being compromises are overcome, with full acceptance as desirable products with a somewhat modified taste!

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