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THE SCIENCE OF ALCOHOL INTOLERANCE: TOXINS, MECHANISMS, AND THE NOREG SOLUTION

Understanding naturally occurring compounds in wine, beer, cocktails and spirits

For generations, wine, beer, cocktails and spirits have been appreciated for their craftsmanship, tradition and character. Modern scientific research suggests that the drinking experience is influenced by far more than alcohol alone.
During fermentation, ageing and production, beverages naturally develop a wide range of compounds that may influence how individuals experience the same beverage.

This report explores the scientific literature surrounding those compounds, the mechanisms associated with common beverage-related reactions, and the research that led to the development of Beverage Refinement.

The objective is not to change the beverage. It is to better understand it.
And to preserve what people already appreciate while refining the experience around it.

FOUNDATIONS OF THIS REPORT

97 Scientific References
3+ Years of Research & Development
Independent Laboratory Validation
U.S. Patented Technology

SCIENTIFIC REVIEW

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Summary

Alcohol intolerance is a prevalent yet frequently underdiagnosed condition, affecting a considerable proportion of the global population. Clinical manifestations range from mild discomfort to severe physiological reactions. While ethanol has traditionally been regarded as the principal causative agent, accumulating evidence indicates that multiple co-occurring compounds, including histamines, sulfites, tyramines, tannins, phenylethylamine, quercetin, acetaldehyde, and glyphosate, play a critical and often under recognized role in mediating these adverse effects.

Each of these compounds exerts toxicity through distinct biological mechanisms. Histamines, for instance, activate immune receptors and trigger allergic responses, whereas acetaldehyde accumulation, often due to impaired aldehyde dehydrogenase activity, contributes to toxicity and hangover symptoms. In addition, quercetin inhibits ALDH2 enzyme (metabolizer of toxic acetaldehyde into harmless acetate), further exacerbating acetaldehyde accumulation and associated adverse outcomes.

The cumulative toxic effects manifest across multiple physiological systems, including dermatological effects such as flushing and dermatitis, gastrointestinal disturbances such as dysbiosis and mucosal irritation, cardiovascular alterations including hypertension and arrhythmias, and respiratory complications such as bronchoconstriction. Moreover, these compounds contribute to hangover-related symptoms, characterized by fatigue, headache, nausea, dehydration, cognitive impairment, and anxiety (commonly referred to as “hangxiety”). Comparative evaluation of existing commercial products revealed that two of the three tested formulations increased histamine levels by 14–22%, while all three elevated acetaldehyde concentrations by 22–78% in white wine substrates, thereby potentially exacerbating toxicity.

In contrast, a five-minute exposure to the NOREG sachet consistently reduced multiple bioactive and toxic compounds, with effects ranging from moderate decreases to complete elimination, including a 100% reduction observed for several compounds across various beverage types. In alcoholic beverages, particularly red and white wines, substantial reductions were observed across all measured toxins, while other alcoholic matrices also demonstrated notable decreases in the majority of compounds. The most pronounced reductions were observed in sulfites and acetaldehydes. In non-alcoholic matrices, tea exhibited reductions in tannin content, whereas coffee demonstrated decreases in histamine and acetaldehyde levels

NOREG is classified as a food contact product rather than a drug, dietary supplement, or medical device, as it acts directly on the beverage prior to consumption. The underlying technology is protected under United States Patent No. 12,435,301, and its efficacy has been evaluated by VG Labs between 2022 and 2026 across eight different beverage types, demonstrating consistent performance under diverse liquid matrices and usage conditions.

ABSTRACT

Alcohol affects people in countless ways, and for those with alcohol intolerance, the experience can often be unpleasant. The science of beverage refinement, aims to educate readers about the compounds commonly found in alcoholic drinks and their potential impacts on health. While this is not a peer-reviewed scientific paper, it is a well-researched resource grounded in over 90 references from credible studies. Our goal is simple: to provide valuable insights to those seeking to better understand these issues and empower them to make informed choices. For those who experience discomfort from alcohol, this report introduces NOREG as a system designed to reduce selected compounds identified in alcoholic beverages.

1. INTRODUCTION

Alcohol has been consumed for thousands of years. Today, alcohol remains the most widely used drug globally, with an average annual consumption of 6.5 liters (1.71 gallons) of pure ethanol per person [1].

Wine has long been associated with triggering migraines. According to the International Headache Society, there are two types of alcohol-induced headaches: immediate (within 3 hours) and delayed (hangover headaches). Delayed headaches, more common in migraine sufferers, may appear hours after consumption, even after the individual falls asleep [2].

Despite the lack of strong associations between alcohol and headache types, alcohol may still trigger individual headache attacks, leading sufferers to reduce or avoid consumption [3].

2. METHODOLOGY

This report was developed with support from laboratory testing conducted by VG Labs, USA (2022–2024), alongside a structured evaluation of the existing scientific literature on toxicants in alcoholic beverages, their properties, adsorption physicochemical mechanisms, exposure pathways, and beverage treatment approaches.

Relevant studies were systematically identified through major scientific databases including PubMed, Scopus, and Google Scholar, using comprehensive search strategies. Core search strings included combinations such as ("alcoholic beverages" OR ethanol) AND (histamine OR sulfites OR acetaldehyde OR tyramine OR phenylethylamine OR quercetin OR tannins) AND ("health effects" OR toxicity OR intolerance OR "adverse reactions"), as well as broader queries targeting systemic effects and fermentation-derived compounds.

The search was limited to publications from 1998 to 2025. Studies were screened and selected based on their relevance to key domains, including physicochemical mechanisms, human exposure and metabolic responses, and applications of food-grade materials for toxin reduction.

Non-peer-reviewed sources and studies lacking direct relevance to these domains were excluded. A narrative synthesis approach was employed to integrate findings across the selected literature, which were then critically compared with NOREG laboratory data to generate a cohesive and scientifically grounded interpretation.

3. ALCOHOL INTOLERANCE

Alcohol intolerance refers to the inability to properly metabolize alcohol, leading to immediate physiological reactions including nasal congestion, flushing, heart dysrhythmias, nausea, and headaches [4].

It encompasses both non-immunologic and immunologic reactions, such as flushing due to acetaldehyde buildup in individuals with a common variation in the aldehyde dehydrogenase (ALDH2) gene, particularly in East Asians, and immune responses like urticaria and asthma exacerbations in susceptible individuals [5].

Alcohol intolerance is frequently linked to flushing syndromes, with two main types: Drug Alcohol Flushing, caused by medications like sulfonylurea antidiabetic drugs, and Simple Alcohol Flushing, prevalent in 3-29% of Western populations and 47-85% of East Asians. Symptoms include redness, nausea, dizziness, and headaches, typically resolving within 1 to 2 hours [6].

Beer-related reactions are primarily due to proteins from malted grains, while wine reactions involve sensitivity to contaminants, sulfites, and biogenic amines. Distilled spirits can cause reactions due to additives and contaminants [7].

Severity varies based on ethanol metabolism and acetaldehyde breakdown, with reduced ALDH enzyme activity, particularly due to genetic variations or medications like disulfiram, leading to acetaldehyde accumulation and heightened alcohol intolerance symptoms [8].

According to a study, 7.2% of respondents in Mainz, Germany, reported wine intolerance, often due to alcohol, histamine, sulfites, or biogenic amines, rather than true allergic reactions involving the immune system. Red wine, containing lipid transfer proteins (LTP), which are naturally occurring plant proteins that can trigger allergic reactions in some individuals [9].

4. MECHANISMS OF TOXICITY

4.1. HISTAMINES:

Histamines, produced by the immune system, play a role in allergic responses by interacting with histamine receptors (H1, H2, H3, and H4), proteins that detect histamine and trigger physiological effects, thereby influencing processes such as vascular permeability and inflammation. High levels of histamines are found in aged, fermented foods, and alcoholic beverages, where they are produced during fermentation. These can trigger headaches, migraines, skin irritation, and respiratory issues such as breathing difficulty and nasal congestion [10].

Histamine, through the H1 receptor, contributes to symptoms like sneezing, nasal congestion, and rhinorrhea, while H2 receptor activation can cause nasal airway swelling. Additionally, H3 and H4 receptors influence neurotransmitter release and inflammation, respectively, amplifying the allergic response and leading to side effects such as nasal congestion and functional impairment [11].

Histamine levels in these foods range from 500 mg/kg [12] [13].

Histamine concentrations in beer range from approximately 21 to 305 µg/L [14].

The histamine content in wine varies widely depending on the type and production process. In red wine, histamine levels range from 60 µg/L to 3,776 µg/L, while in rosé wine, the range is 15 µg/L to 61 µg/L. White wine typically contains histamine levels between 3 µg/L and 120 µg/L, and dessert wines from 80 µg/L to 400 µg/L. Histamine in sparkling wine or champagne shows levels from 15 µg/L to 6,670 µg/L [15].

4.2. SULFITES

Sulfites including sulfur dioxide, are by products of yeast metabolism in fermentation and are used as preservatives in all wines [16]. They are found in concentrations from 10 to 350+ parts per million [16] [17], with white wines typically containing more sulfites than red [18]. In sensitive individuals, sulfites can cause bronchoconstriction, skin rashes, nausea, and exacerbate asthma symptoms. Sulfites can trigger histamine release and interact with prostaglandin and leukotriene pathways, leading to asthma like reactions [19]. Wines with more than 10 parts per million of sulfites must be labeled.

4.3. ACETALDEHYDE:

Acetaldehyde, a byproduct of alcohol fermentation, is also classified as a congener—a substance produced during fermentation and distillation that contributes to the flavor, aroma, and character of alcoholic beverages. Acetaldehyde is particularly present in darker drinks like red wine, whiskey, and dark rum [20], where its levels tend to be higher compared to lighter beverages. While congeners like acetaldehyde enhance the sensory experience of drinking, they are also associated with negative effects, such as worsening hangover symptoms, due to their toxic properties when consumed in excess. Its levels vary across beverages, with spirits having the highest concentrations (66 ± 101 mg/L) [21]. Acetaldehyde can overwhelm the body's ability to metabolize it, leading to inflammatory responses and symptoms such as headaches, fatigue, and nausea. These effects are more pronounced with darker alcoholic drinks, contributing to intense hangovers and other discomforts [18]. While the body can break down small amounts of acetaldehyde from food, higher levels from alcohol consumption overwhelm the system [20].

4.4. TANNINS:

Tannins are naturally occurring chemical compounds, classified as polyphenols, found in many plants (8.148% w/w) [22]. In grapes, tannins are primarily located in the skin, seeds, and stems, where they act as a defense mechanism. During winemaking, tannins can also be introduced from the wood barrels used for aging, contributing to the flavor and structure of the wine [23]. Their concentration in red wine ranges from 500 to 1500 mg/L [24]. These compounds contribute to the texture and mouthfeel of wine, creating an astringent, bitter sensation by binding with proteins in saliva, which can range from soft to grainy [21]. Tannins offer several health benefits due to their antioxidant properties, including lowering cholesterol, reducing blood pressure, and stimulating the immune system. They also have antibacterial properties, which can help fight tooth decay. However, tannins can cause negative side effects like nausea, vomiting, diarrhea, rash, headaches, shortness of breath, and swelling of the lips or throat, particularly in sensitive individuals [25]. They reduce nutrient absorption, disrupt protein digestibility, and may contribute to carcinogenicity through associated compounds. Additionally, tannins can alter oxidative stress, exhibit antimicrobial activity, and induce liver damage and immune modulation, depending on their type and dosage [26].

4.5. PHENYLETHYLAMINE:

97% of red wines [27, 28]. It plays a key role in producing brain signaling molecules, such as dopamine, norepinephrine (noradrenaline), and epinephrine (adrenaline), which contribute to increased mood, focus, and energy [29]. In the human body, phenylethylamine can cause side effects such as headaches, anxiety, rapid heart rate, and overstimulation [30]. Phenylethylamine may elevate serotonin levels in the brain, and when combined with medications that also increase serotonin, it can lead to excessive serotonin accumulation. This condition may result in severe adverse effects, including heart complications, seizures, and vomiting [31].

4.6. TYRAMINE:

Tyramine is a naturally occurring amino acid found in many foods, including smoked or processed meats, pickled or fermented foods [32]. Some alcoholic beverages, especially those that are aged or fermented, can contain high levels of tyramine i.e. 0.98 to 3.21 mg/l in beer and nonalcoholic beers from 0.52 to 3.96mg/l [33, 34]. It tightens blood vessels, leading to an increase in blood pressure. It can also trigger headaches, particularly in individuals prone to migraines, by initiating a chain reaction of selective cerebral vasoconstriction followed by rebound dilation of the cranial vessels. This process is a common cause of the throbbing pain associated with migraines. Other side effects and intolerance symptoms of tyramine include nausea, sweating, rapid heart rate, chest pain, and shortness of breath [35].

4.7. QUERCETIN:

Quercetin is a flavonoid, a group of plant pigments that comprised of 76–1470 mg/kg DW [36] responsible for the color of many fruits. It is found in foods like red wine (5 to 104.7 µmoles) [37], onions, green tea, apples, and berries. As a natural antioxidant, quercetin exhibits anti-inflammatory effects and may help improve inflammation, blood pressure, exercise performance, and blood sugar management. Quercetin, is a type of flavonoid, helps protect the body by neutralizing harmful free radicals, thereby reducing oxidative stress [38]. However, Quercetin in red wine inhibits ALDH2, the enzyme that breaks down acetaldehyde, a toxic byproduct of alcohol metabolism. This leads to acetaldehyde buildup, causing headaches in susceptible individual especially those with dysfunctional ALDH2. Red wine's high quercetin levels make it more problematic than other alcoholic beverages [39]. In terms of its interaction with the human body, quercetin may cause side effects like headaches and an upset stomach [38].

4.8. GLYPHOSATE

Glyphosate is a widely used organophosphate herbicide applied in agriculture to control weeds in crops [40]. Due to its widespread use, trace residues have been detected in a variety of foods. These residues can persist in the ingredients (malt, grapes and corn etc) used for the production of wine, beer, and spirits, thereby entering the manufacturing chain and potentially contributing to the final composition of alcoholic beverages [41]. Glyphosate is human carcinogen (Group 2A) that could potentially contribute to immune system disturbance, microbiota dysbiosis and an increased risk of cancers [42, 43, 44]. Even its low doses such as 1 part per trillion could stimulate the growth of breast cancer cells and disrupt hormone systems [42]. U.S. PIRG Education Fund found high glyphosate level in different commercial beers and wines with highest level ranging from 25 ppb to 51 ppb [42]. Other food products such as tea products (40–728 ppb in five samples), and coffee powder (11 and 26 ppb in two samples) showed various levels of glyphosate contamination. Glyphosate was also detected in human urine samples, in particular at elevated levels (2 fold) from participants who consumed tea in the past 24 h [45].

5. SYMPTOMS OF TOXINS IN ALCOHOL

5.1. IMPACTS OF ALCOHOL CONSUMPTION AND ASSOCIATED COMPOUNDS (IACAC) ON SKIN:

Alcohol consumption can exacerbate dermatitis issues, a term encompassing skin inflammation, due to various irritating and allergenic ingredients in alcoholic beverages [46]. Key contributors include sulfites, histamines, acetaldehyde, tyramine, tannins, congeners, and phenylethylamine. Alcohol's dehydrating effects can lead to dry skin, which is more susceptible to irritation and can worsen existing dermatitis [47]. Facial flushing, often termed "Asian flush" or "alcohol flush reaction," is largely attributed to acetaldehyde, a byproduct of alcohol metabolism. When alcohol is consumed, acetaldehyde can build up in the body, leading to the dilation of blood vessels in the skin. This results in facial redness, warmth, and flushing [48]. Histamine release from alcohol can further contribute to symptoms such as itching, hives, and skin redness [49]. Moreover, certain ingredients such as sulfites used as a preservatives and flavorings agent results in causing allergic reactions, manifesting as skin irritation [50]. Excessive alcohol intake may also suppress the immune system, increasing the skin's vulnerability to infections and delaying the healing of pre existing skin issues, thereby complicating dermatitis management [51]. Quercetin in alcohol, particularly in red wine, is problematic because its metabolite, quercetin 3 glucuronide, inhibits ALDH2 with an IC50 of 9.6 μM. ALDH2 is responsible for metabolizing acetaldehyde, a toxic byproduct of alcohol metabolism. Inhibition of ALDH2 leads to the accumulation of acetaldehyde,
which is associated with flushing and headaches, particularly in individuals with a dysfunctional ALDH2 gene. Red wine contains significantly higher levels of quercetin and its glycosides compared to other alcoholic beverages, making it more likely to cause headaches in susceptible individuals [52].

5.2. IACAC ON GASTROINTESTINAL HEALTH:

Alcohol consumption can negatively impact the gastrointestinal (GI) system, aggravating conditions like gastritis, inflammatory bowel diseases, and irritable bowel syndrome (IBS). It irritates the stomach lining, increases stomach acid, and disrupts nutrient absorption. Alcohol can also alter gut microbiota, contributing to dysbiosis and related GI disorders. Chronic use may inflame the pancreas (pancreatitis) and affect liver function, worsening digestive issues. As a diuretic, alcohol leads to dehydration, which can exacerbate constipation [53]. Sulfites, commonly used as preservatives, can trigger asthma-like symptoms or gastrointestinal iscomfort [54]. Histamines and tyramines, often found in fermented products, are associated with gastrointestinal issues like diarrhea, stomach cramps, nausea, and vomiting [55]. Acetaldehyde, a toxic byproduct of alcohol metabolism, can cause stomach pain and nausea [56]. Tannins and phenylethylamine, while less frequently linked to severe reactions, may contribute to symptoms like headaches or digestive discomfort in some individuals [57]. The gastrointestinal response to these ingredients can manifest in various forms, including irritation, increased stomach acid, delayed digestion, and changes in gut microbiota, ultimately exacerbating preexisting conditions such as irritable bowel syndrome (IBS) or gastritis [53].

5.3. IACAC ON CARDIOVASCULAR AND RESPIRATORY SYSTEM:

Alcohol consumption can significantly affect the cardiovascular system, potentially worsening heart and blood pressure issues. It can temporarily raise blood pressure, and chronic heavy drinking may lead to hypertension, a major risk factor for heart disease and stroke. Excessive alcohol use can weaken heart muscles, cause alcoholic cardiomyopathy and increase the risk of heart failure. It can also disrupt heart rhythms, leading to arrhythmias, and heighten the risk of stroke by promoting blood clots or ruptured blood vessels. Additionally, alcohol may interfere with heart medications, worsen cholesterol levels, and affect blood clotting. As a diuretic, it causes dehydration, which can further strain the cardiovascular system [58]. Histamines and tyramines are often linked to rapid heart rate and low blood pressure due to their vasodilatory effects [59, 60]. Conversely, tannins and acetaldehyde can lead to increased blood pressure by affecting blood vessel constriction [61]. Chronic alcohol use can exacerbate heart conditions, potentially leading arrhythmias, or to hypertension, cardiomyopathy [58]. Alcohol consumption can influence both the cardiovascular and respiratory systems through its direct physiological effects as well as the action of specific bioactive compounds. Histamines and tyramines present in alcoholic beverages may induce tachycardia and alterations in blood pressure [59,60]. Additionally, congeners such as acetaldehyde and tannins can contribute to elevated blood pressure through vasoconstrictive mechanisms [61]. Within the respiratory system, alcohol acts as a central nervous system depressant and may suppress the respiratory center, leading to reduced breathing rate and an increased risk of aspiration during intoxication [62]. Furthermore, sulfites commonly found in alcoholic beverages can provoke respiratory symptoms in susceptible individuals, exacerbating conditions such as asthma, bronchoconstriction, and general breathing discomfort [63].

5.4. IACAC IN EXACERBATING HAY FEVER SYMPTOMS:

Alcohol can exacerbate hay fever (allergic rhinitis) symptoms through various mechanisms [68]. Histamines in alcohol trigger allergic responses, leading to sneezing, runny nose, and congestion [69]. Sulfites, found in some alcoholic beverages, can worsen respiratory symptoms like coughing [70]. Vasodilation caused by alcohol may lead to nasal congestion, while dehydration from alcohol can dry out mucous membranes, increasing irritation [71]. In sensitive individuals, alcohol might lower the threshold for reacting to allergens, intensifying hay fever symptoms [72]. Excessive alcohol use may also weaken the immune system, enhancing the allergic response [55].

5.5. IACAC INDUCED HANGOVER AND HANGXIETY:

Hangxiety refers to post-drinking anxiety, characterized by feelings of worry, irritability, or restlessness after alcohol consumption. It results from chemical changes in the brain, where alcohol initially enhances GABA (promoting relaxation) and suppresses glutamate (reducing anxiety). However, as alcohol wears off, GABA decreases, and glutamate increases, leading to heightened anxiety. Those with preexisting anxiety are more prone to hangxiety, which typically peaks when blood alcohol levels return to zero and can last over 24 hours, depending on factors like alcohol intake, body size, and liver health. Memory gaps may worsen hangxiety, making it beneficial to moderate alcohol consumption or seek support [64]. Alcohol significantly impacts the body, leading to hangover and "hangxiety" (anxiety from a hangover) due to various physiological changes. A major factor is dehydration, as alcohol acts as a diuretic, increasing urine production and causing headaches, fatigue, and dizziness. Alcohol can also trigger an inflammatory response, contributing to headaches and muscle aches. While it induces initial sleepiness, alcohol disrupts

sleep patterns, particularly restorative stages, leading to grogginess. The accumulation of acetaldehyde, a toxic byproduct of alcohol metabolism, is associated with hangover symptoms. Alcohol irritates the stomach lining, causing gastrointestinal distress such as nausea and vomiting. Fluctuations in blood sugar levels can result in weakness and irritability, potentially exacerbating hangxiety. Moreover, alcohol disrupts neurotransmitter balance in the brain, affecting mood and anxiety Psychological factors, including regret or guilt over actions taken while intoxicated, can enhance feelings of hangxiety. Although hangovers are attributed to ethanol's effects, other constituents can exacerbate symptoms but are not the main causes. The primary driver of hangover severity is the amount of untreated alcohol consumed.

5.6. IACAC INDUCED HEADACHES AND MIGRAINES:

Alcohol consumption can trigger headaches and migraines in some individuals due to several mechanisms. Alcohol can trigger headaches and mechanisms vasodilation, such and migraines as through dehydration, histamine release, particularly from beverages like red wine. Firstly, alcohol acts as a diuretic, increasing urine production and leading to dehydration, a known headache trigger. Additionally, alcohol causes vasodilation, or the widening of blood vessels, which can contribute to headache pain, especially in those prone to migraines. Certain alcoholic beverages, such as red wine and beer, release histamines that may also induce headaches in sensitive individuals. The presence of tyramine in some alcohols can affect blood vessel constriction and dilation, potentially triggering migraines. Moreover, withdrawal symptoms, including headaches, can occur in those who regularly consume alcohol and suddenly reduce their intake. Sensitivities to sulfites and tannins found in drinks like red wine may further exacerbate headaches in some people. Alcohol can alter neurotransmitter levels, particularly serotonin, which is linked to migraine occurrences, indicating that individual responses to alcohol may vary widely. Vertigo may occur as alcohol suppresses vestibular function in the inner ear, affecting balance.

5.7. IACAC INDUCED INTOLERANCE AND ALLERGIC REACTIONS:

Alcohol intolerance and allergic reactions to alcohol are distinct but often overlapping conditions. Intolerance is caused by a deficiency in aldehyde dehydrogenase, leading to facial flushing, nausea, rapid heartbeat, and gastrointestinal discomfort. Alcohol can also stimulate histamine release, resulting in itching and hives. Allergic reactions may stem from allergens in alcoholic beverages, such as proteins from grains or grapes, histamine, and tyramine, causing swelling and inflammation. Substances like sulfites and tannins can worsen symptoms, causing headaches and respiratory issues. Overall, individuals may experience muscle aches, weakness, chills, insomnia, fatigue, and sweating, with varying responses.

6. HEALTH EFFECTS OF KEY COMPOUNDS IN ALCOHOLIC BEVERAGES

Different alcoholic beverages contain varying levels of compounds that can lead to a range of adverse health effects (Table 1).

- **Acetaldehyde,** which causes severe hangovers, fatigue, and nausea, is found in high levels in dark liquors like bourbon (1746 µg/L) and red wine (1267 µg/L) but is significantly lower in vodka (48 µg/L) and gin (21 µg/L).
- **Phenylethylamine,** associated with headaches and anxiety, is primarily found in red wines (0.7 mg/L) compared to lower levels in white wines (0.4 mg/L).
- **Quercetin,** which can upset the stomach and cause headaches, is highly variable in red wines (7–171 mg/L) depending on sunlight exposure, while white wines contain much less (0.83 mg/100 mL).
- **Sulfites,** known to exacerbate asthma and cause skin reactions, are abundant in red wine (150 mg/L), white wine (200 mg/L), and beer but are naturally occurring at lower levels in organic wines and distilled spirits like vodka and gin.
- **Histamines,** responsible for migraines, skin irritation, and breathing difficulties, are abundant in red wine (30 mg/kg) and champagne (670 mg/kg) but are minimal in tequila and white wine.
- **Tannins,** which trigger migraines and gastrointestinal discomfort, are most concentrated in red wines (0.4–50 mg/L) and barrel-aged liquors, while lighter beverages like white wine and beer contain significantly less (1.5 mg/L).
- **Tyramine,** linked to headaches and rapid heart rate, is present in barley beer and white wine (8.31 mg/L) but is much lower in red wine (0.06–0.7 mg/L) and spirits like vodka and whiskey (Table 1).
- **Glyphosate** is human carcinogen. Even its low doses such as 1 part per trillion could stimulate the growth of breast cancer cells. Its residues can persist in the ingredients (malt, grapes and corn etc.) used to produce wine, beer, and spirit.

7. THE NOREG MECHANISM

Adsorption refers to the accumulation of molecules on the surface of a solid material, rather than their penetration into its internal structure, which is termed absorption [65]. In the NOREG sachet system, this principle facilitates the surface-level capture of selected compounds present in the beverage without altering its overall composition or requiring ingestion.

This mechanism is governed by well established physicochemical interactions.

Van der Waals forces, which are weak, short range attractive interactions between molecules, enable the temporary binding of target compounds to the sachet surface. In addition, electrostatic interactions play a critical role, arising from the attraction between oppositely charged entities [66]. Charged molecules within the beverage such as Glyphosate (anionic) are oppositely selectively charged attracted elements to (cationic Chitosan) on the sachet material, promoting

preferential adsorption of compatible compounds [67]. Importantly, the sachet operates directly within the beverage prior to consumption, reducing the concentration of targeted compounds before they enter the body. This contrasts with oral supplements, which act post-ingestion and depend on systemic absorption and metabolic processing to exert their effects. Oral supplementation relies on gastrointestinal digestion and absorption, processes that exhibit considerable variability. . inter-individual

Consequently, therapeutic outcomes may be inconsistent. In contrast, NOREG treatment demonstrates greater efficacy by circumventing these limitations.Independent testing has demonstrated that the alcohol content and pH of the beverage remain unchanged following sachet application, indicatingthat the process does not alter the fundamental physicochemical properties of the liquid. This adsorption-based mechanism is further supported within the framework of United States Patent No. 12,435,301.

8. REGULATORY CONSIDERATIONS

NOREG is classified as a food contact product, rather than a drug, dietary supplement, or medical device. This means that the system interacts exclusively with the beverage matrix and does not introduce any active therapeutic substance into the human body. Drug-based or dietary supplement interventions are comparatively less advantageous in this context because they depend on gastrointestinal absorption, systemic distribution, and metabolic processing before exerting any interaction with target toxicants. These pharmacokinetic constraints can delay onset of action, reduce effective bioavailability, and introduce substantial inter-individual variability in outcomes. Additionally, such approaches may result in unintended systemic exposure and off target effects. In contrast, NOREG operates directly within the beverage matrix, enabling immediate interaction with toxicants at the point of consumption while avoiding systemic absorption and metabolic transformation. NOREG is developed in accordance with established U.S. FDA food safety regulations, including 21 CFR Parts 170–186, which govern food ingredients and safety standards, and 21 CFR 173.25, which pertains to approved processing aids used in food treatment [68]. In contrast, 21 CFR 173.25 specifically permits the use of ion-exchange resins in food processing for purification purposes, such as removing unwanted ions or contaminants from food and water [69]. These regulations support NOREG's classification as a compliant food-contact technology, ensuring it meets recognized safety and regulatory expectations. Importantly, this offers a clear commercial advantage. As a food contact system, NOREG follows a simpler regulatory (Food-contact system) pathway than pharmaceuticals or medical devices. This supports faster and easier international regulatory alignment. It also enables smooth white-label integration across beverage industries and strengthens the global distribution potential while remaining within established food safety standards, giving partners greater confidence in adoption. NOREG can be rebranded as "purification sachet" and can be adopted in the beverage industry as a white-label solution. It offers flexibility across multiple use cases: it can be included as an add-on sachet packaged with beverages, integrated into production workflows as a processing aid, or marketed as a value-added feature (e.g., "enhanced purity" or "toxin-reduced formulation"). This allows beverage companies to differentiate their products, strengthen quality assurance claims, and respond to consumer demand for safer and cleaner consumption options, while leveraging NOREG's functionality without investing in proprietary R&D or regulatory development.

9. THE NOREG EFFECT

9.1. TOXIN REDUCTION PER CONSTITUENT

NOREG sachets reduced different toxins in alcoholic and non-alcoholic products in 5 minute controlled laboratory tests. Histamine exhibited complete reduction (100%) in whiskey, beer, tequila, and coffee. Similarly, tyramine also showed near -complete reduction across these beverages (94–100%), with moderate reductions observed in red wine (59-68%) and white wine (30–53%). In contrast, sulfites displayed complete reduction only in tequila, significant reduction in beer (75%), and moderate reductions in whiskey (50%), cider (50%), and white wines (37%). Additionally, acetaldehyde was completely detoxified in red wine (100%) and showed moderate reduction in beer (71%), whiskey (53%), and tequila (50%). Tannins were reduced to higher extent (76%) in tea. Other toxins such as phenylethylamine and quercetin exhibited low to moderate reductions across various substrates, including wine, whiskey, beer, tequila, cider, and coffee. Overall, alcoholic beverages, particularly wines and spirits, exhibit the greatest reductions across all toxins, while non-alcoholic drinks primarily reduce tannins at moderate levels (Figure 1) (Table 2).

9.2. COMPARISON OF ALKAA AND COMMERCIALLY AVAILABLE PRODUCTS

In controlled laboratory conditions, NOREG showed greater reductions across measured compounds compared to selected comparator products across all measured parameters. Unlike these products—which are primarily designed to target wine, leaving consumers unprotected when drinking beer, spirits, or other types of alcohol—NOREG is engineered to treat a wide range of alcoholic beverages. Surprisingly, two of the three commercial products increased the toxicity of histamine (14%–22%), and all three increased the toxicity of acetaldehyde (22%–78%) in white wine substrates (Figure 2). In contrast, NOREG reduced toxins in red/white wine, beer, whisky, tequila, ciders, coffee, and tea (Figure 1).

Interestingly, NOREG demonstrated a 12.8% reduction in glyphosate levels, despite not being specifically engineered for herbicide removal. NOREG was primarily designed to target fermentation by products and biogenic amines; therefore, this modest reduction suggests that its adsorption matrix may extend beyond its intended scope. Further targeted studies are warranted to better characterize and validate this effect.

10. SCIENTIFIC BACKING AND REFERENCES

NOREG sachets are formulated with carefully selected compounds that reduce toxins in alcoholic beverages responsible for dozens of alcohol intolerance symptoms (Table 1). Testing shows that the alcohol percentage remains unchanged, and the pH level is not altered after treatment with NOREG. This testing mechanism is covered under U.S. Patent No. 12,435,301 (granted). However, the ingredients are widely used in food, beverage, and pharmaceutical industries for various applications, with their safety and efficacy documented innumerous studies and reports. Additionally, all ingredients used in NOREG comply with applicable FDA regulations, including 21 CFR 170-186 and FDA Regulation 21 CFR 173.25 for Food Treatment. NOREG comprises special ingredients that substantially detoxify the sulfites, as demonstrated by numerous studies. In a study, the efficacy of one of the NOREG ingredients (ALG) for reducing sulfur dioxide (SO_2) in distilled grape spirits, achieving levels below 1.00 mg/L with a 2.0 g/L dosage within 12 hours [70]. A study demonstrated its efficacy in reducing sulfate removal by 41.6% using a soil-charcoal mixture [71].

Table 1. COMPARISON OF TOXIN LEVELS AND THEIR ASSOCIATED SIDE EFFECTS IN DIFFERENT ALCOHOLIC BEVERAGES

Toxin	Side Effects	High congener (range of toxin)	References
ACETALDEHYDE	Intense hangovers, fatigue, severe next day headaches, flushing, increased skin temperature, weakness, muscle aches, dry mouth and nausea	- Bourbon, - Scotch Whisky (1746 µM), - World Whiskeys, - Red Wine (1267 µM), - Brandy, - Tequila (530 µM), - Dark Beer (233 µM), - Stouts, - Dark Rum (3110 µM). - Vodka (48 µM), - Gin (21 µM), - Light Rum (403 µM), - Lagers, - White Wine (1521 µM), - Champagne	[72]
HISTAMINES	Headache, migraines, itchy skin, redness, red/hot face, congestion, migraine, breathing trouble, diarrhea, stomach pain, skin irritation.	- Red Wine (30mg/kg), - Beer, - Champagnes (670mg/kg) - Tequila, - Rum, - Vodka, - Gin, - White wine	[73]
PHENYLETHYLAMINE	Headaches, anxiety, rapid heart rate, overstimulation	- Red wines (0.7mg/l) - White wines (0.4mg/l), - Beer.	[74]
QUERCETIN	Headaches, upset stomach	- Red wines (Cabernet - Sauvignon, Malbec, Syrah) (7–171 mg/L). Levels vary dramatically depending on the amount of sunlight that the grapes are exposed to prior to harvest. - White wines (0.83 mg/100 ml)	[75,76]
SULFITES	Itchy skin, red blotches, flushing, rashes, hives, diarrhea, stomach cramps, nausea, wheezing, difficulty breathing, coughing, chest tightness, anxiety, weakness. Sulfites are known to exacerbate asthma symptoms in people with asthma.	- Beer, Red wine (150 mg/L), - White wine (200 mg/L), - Brown liquor, ciders (5%) - Sake, - Vodka (40%), - Gin (42%), - Lite Beers (4.30%), - Organic wine (naturallyoccurring sulfites only)	[77,78]
TANNINS	Nausea, vomiting, diarrhea, bowel irritation, runny nose, rash, hives, itching, stomachache, headaches, migraines, shortness of breath, swelling of lips, mouth or throat.	- Red wines (Cabernet - Sauvignon, Malbec, Syrah) (0.4-50 mg/l), - Blanco tequila - White wines, Beer (1.5mg/l), - Whiskey, Barrel aged alcohols (from oak casks) - Others: Coffee, Black Tea, Green Tea	[79]
TYRAMINE	Headaches, migraine headaches, nausea, sweating, rapid heart rate, chest pain, shortness of breath.	- Barley Beer, White wine (8.31mg/l), - Non alcoholic (Vermouth, Sherry, Soy Sauce, - Worcestershire Sauce) (0.60–3.30 mg/l) - Red wine (0.06–0.7 mg/l), - Vodka, - Whiskey, - Wheat Beer, - Ciders	[80, 81]
GLYPHOSATE	Skin and eye irritation, sore throat, nausea, vomiting, and diarrhea	- Wine (5 – 51 ppb) - Neutral grain spirits (<0.075 µg/L)	[80, 81]

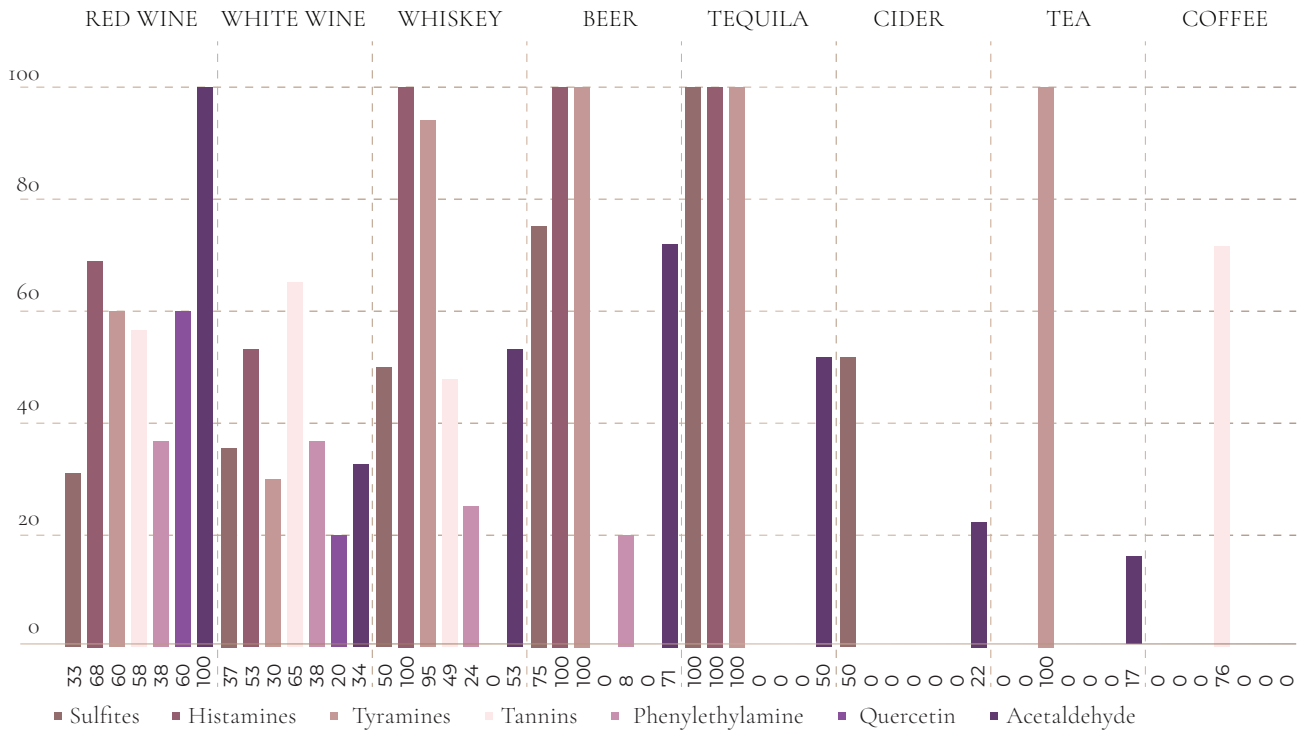

Figure 1. Percent Reduction of Toxins in 5 min by NOREG Tagged Sachet. See Table 2 for before/after levels. A zero (0) in above chart = toxin not detectable at time of test.

Table 2. BEFORE AND AFTER TOXIN LEVELS WITH AND WITHOUT NOREG.

Product		Red Wine	White Wine	Whiskey	Beer	Tequila	Cider	Tea	Coffee
Amount of liquid		6.0 oz / 186 ml	6.0 oz / 186 ml	2.0 oz / 59 ml	12.0 oz / 355 ml	2.0 oz / 59 ml	6.0 oz / 186 ml	6.0 oz / 186 ml	8.0 oz / 250 ml
Sulfites	*Before Level*	6.000	30.000	4.000	8.000	0.600	2.000	ND	ND
	After 5 minute exposure, sachet movement up/down	4.000	19.000	2.000	2.000	0.000	1.000	ND	ND
Histamines	*Before Level*	75.850	168.200	0.080	0.300	0.000	ND	ND	0.200
	After 5 minute exposure, sachet movement up/down	24.250	78.360	0.000	0.030	0.000	ND	ND	0.200
Tyramines	*Before Level*	389.000	42.80	37.000	80.000	15.000	ND	ND	ND
	After 5 minute exposure, sachet movement up/down	156.000	29.898	2.000	0.000	0.000	ND	ND	ND
Tannins	*Before Level*	315.000	78.610	121.000	ND	ND	ND	604.86	ND
	After 5 minute exposure, sachet movement up/down	132.000	27.160	62.000	ND	ND	ND	463.252	ND
Phenylethylamine	*Before Level*	3.21	75.67	0.250	0.354	ND	ND	ND	ND
	After 5 minute exposure, sachet movement up/down	1.98	47.01	0.190	0.330	ND	ND	ND	ND
Quercetin	*Before Level*	1.23	0.59	ND*	ND	ND	ND	ND	ND
	After 5 minute exposure, sachet movement up/down	0.49	0.47	ND	ND	ND	ND	ND	ND
Acetaldehyde	*Before Level*	0.150	0.42668	25.800	0.0690	0.200	1.47486	ND	16.200
	After 5 minute exposure, sachet movement up/down	0.000	0.28296	12.000	26.000	13.000	1.14956	ND	16.200

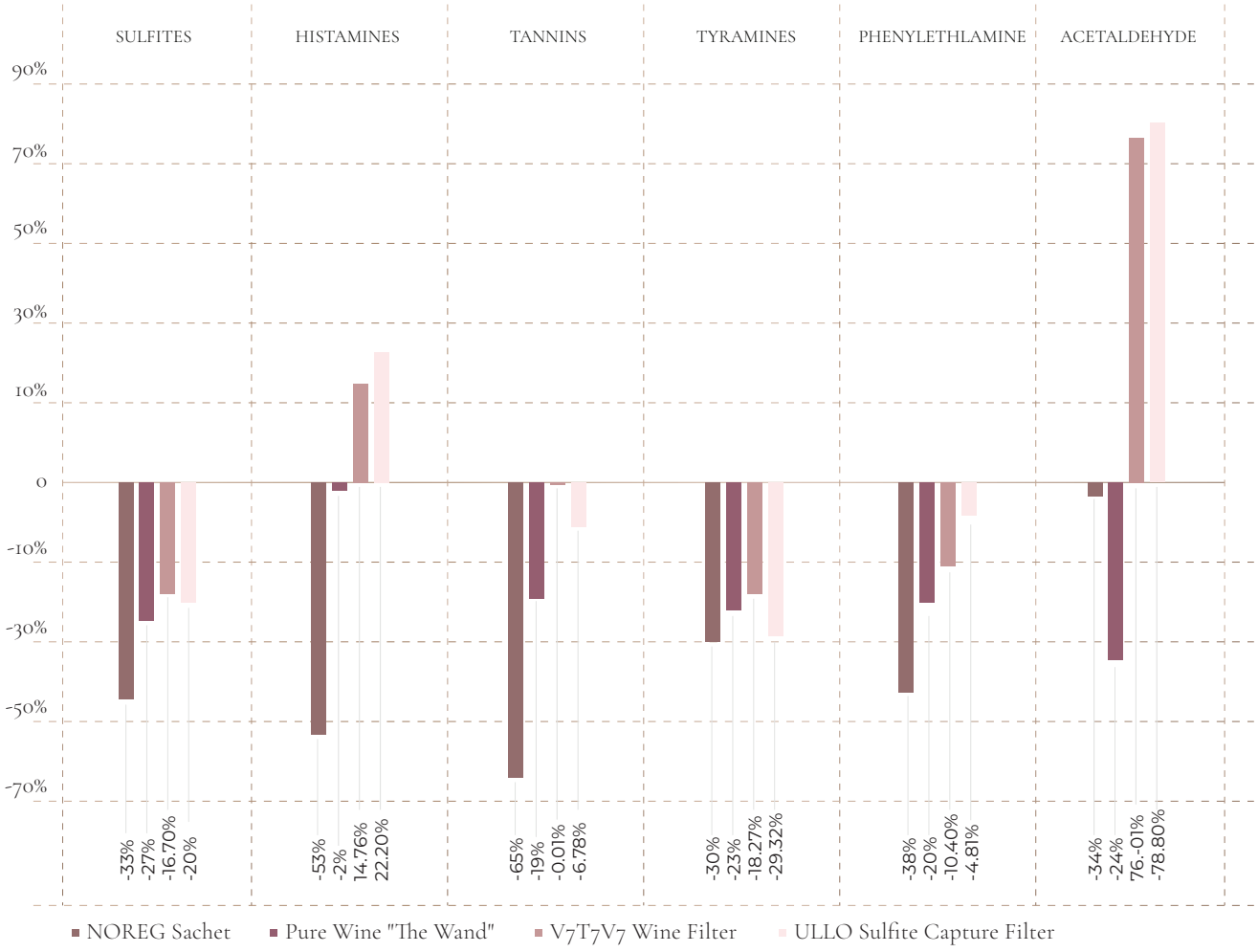

Figure 2. Percent Reduction of Toxins in 5 min by NOREG Tagged Sachet and three (3) other commercially available products for use in wine. NOREG Competitive Analysis Laboratory Testing – August 2022. White Wine "Barefoot Chardonay". VG Labs, USA.

Efficacy of NOREG Sachet 5 Minutes in 6.0 oz / 186 ml wine. Analytes: Sulfites, Histamines, Tyramines, Tannins, Phenylethylamine, Quercetin, Acetaldehyde. Lead chemist: Robert S

Some scientists combined two ALGs for wine treatment, reducing sulfites from 47–144 ppm. to below 10 ppm, with some samples achieving complete removal [82]. Another study from USA extended these treatments to red wine, achieving a 30% reduction in free sulfites and 86.2% reduction in histamine emphasizing ALGs versatility in mitigating noxious compounds across industries [83]. Studies have also demonstrated the efficacy of ALG in detoxifying biogenic amines, including histamine and tryptamine. Notably, in anchovy fish sauce, tryptamine was completely eliminated [84]. Furthermore, ALG based Method effectively reduced histamines and tyramines in wine samples, achieving purified wine between 93% and 100% [85]. While Pena-Gallego reported the detoxification of histamine in the range of 94.3–95.6% and tyramine 64.8-78.9% [86]. NOREG reduced sulfites, histamines, and tyramines effectively due to the adsorption capacity of ALG, which binds these small, polar molecules through van der Waals forces and surface interaction. It adsorbs polar molecules and selective ion replacement, where certain ions in

its structure are replaced by ions from the surrounding solution, further enhancing its ability to target and remove specific compounds such as sulfites, histamines, and tyramines across a range of solvents enhancing its versatility across solvents. Our results further demonstrated that quercetin showed no reduction in most substrates, such as whiskey, beer, tequila, cider, coffee, and tea, except in wine products. Researchers reported that quercetin in wine can be reduced by 95%using ALG-based products [87]. Quercetin concentrations in red wine could be reduced from 91 mg/L to below 5 mg/L [88]. The reduction of quercetin in wine by ALG-based products is likely due to wine's unique composition, including its high polyphenol content, acidic pH (3-4), and ethanol concentration (8-15%). These factors enhance quercetin's solubility and reactivity, facilitating its interaction with ALG, unlike other beverages with lower polyphenol levels, higher pH, or differing matrix compositions [89] [90]. While acetaldehyde and tannins were among the reduced toxins, acetaldehyde reduction was most notable in wine, whereas tannins were reduced across nearly all alcoholic beverages. In a study, the differential reduction of acetaldehyde and tannins in alcoholic beverages is influenced by their distinct chemical properties and processing interactions. Acetaldehyde reduction is more prominent in wine products due to its reactivity with sulfur dioxide (SO_2), a common wine preservative, which binds and reduces its free concentration [91]. metabolism during Additionally, fermentation yeast converts acetaldehyde into ethanol, further lowering its levels [92]. In contrast, tannins, stable polyphenols derived from sources like grape skins, barley, and oak barrels, persist beverages across most alcoholics due to their non-volatile, chemically stable nature and incorporation during aging and processing [93] [94]. Lab test results further demonstrated that toxin reduction was least observed in tea and coffee. The reduced detoxification in tea and coffee may be due to their lower toxicity compared to alcohol-based beverages, which contain harmful compounds like acetaldehyde and sulfites. Additionally, the pH and solvent interactions in these beverages may limit adsorption efficiency.

11. CONCLUSION

NOREG is a non-ingested filtration system designed to improve the quality of alcoholic beverages by reducing a wide range of noxious compounds, including sulfites, histamines, tannins, tyramine, acetaldehyde (congeners), phenylethylamine, and quercetin—substances often associated with adverse effects such as headaches, nausea, and other discomforts. By capturing these compounds before consumption, NOREG helps reduce exposure to elements that may contribute to alcohol intolerance. Additionally, because its ingredients function externally rather than within the body, NOREG qualifies as a food contact product rather than a drug, ensuring a straightforward regulatory path without altering ethanol content or core beverage characteristics. For product samples, partnership inquiries, or additional scientific documentation, please contact

office@noreg.se
or visit www.noreg.se

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