



A Study on Formulation and Evaluation of Phytochemicals, Polyphenols and Antioxidants Activity of Herbal Grape Wine Incorporated with Fresh Turmeric Rhizome (*Curcuma longa*)

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10.18805/ajdfr.DR-2388

ABSTRACT

Background: Herbal-infused wines enriched with plant-based bioactive compounds offer both nutritional and therapeutic benefits due to their potent anti-inflammatory and cardioprotective properties. This study aimed to formulate herbal grape wine infused with fresh turmeric rhizome (*Curcuma longa*) in two different preparation methods and to evaluate its various functional properties.

Methods: Two wine variants are prepared using diced turmeric rhizome (W-DTR) and with turmeric rhizome extract (W-TRE), followed by 15 days of fermentation at an optimum fermentation temperature of 23°C and an inoculum concentration of 5% (v/v) (*Saccharomyces cerevisiae*) and Turmeric extract and diced turmeric concentration of 10% (v/v). Samples were analyzed for qualitative phytochemical screening, total phenol, total flavonoid, curcumin, resveratrol content and Antioxidant activity (AOA).

Result: Both the variants demonstrated favorable functional traits. Also, W-TRE (66.022 CE mg/g) exhibited significantly higher curcumin content when compared to W-DTR (61.056 CE mg/g). Both wines possessed significant resveratrol and showed notable antioxidant activity when compared with control. Therefore it can be concluded from the current research findings that the synergistic combination of grapes and turmeric can significantly enhanced the polyphenolic content and antioxidant activity of the grape wine.

Key words: *Curcuma longa*, Curcumin, Diced turmeric rhizome, Herbal wine, Turmeric rhizome extract.

INTRODUCTION

Fermentation, stemming from the Latin term fermentum, describes the anaerobic metabolic process of microorganisms converting carbohydrates into substances like alcohol and acids (Šikić-Pogačar *et al.*, 2022). This traditional technique is both efficient and essential for food preservation, enhancing shelf life and producing fermented products like wine, beer, bread and cheese (Morales-de *et al.*, 2023; Vahini *et al.*, 2023). The fermentation industry utilizes microbes like yeasts, molds and lactic acid bacteria to produce valuable compounds, including alcohol, acids and enzymes (Pinto *et al.*, 2023).

Fermentation of grapes generally promotes the release of bioactive compounds present in grapes, such as flavonoids, phenols, resveratrol, vitamins and minerals other phytochemicals into the wine (Lodolo *et al.*, 2008). Grape wine possesses a rich phytochemical profile and associated health benefits (Balanov *et al.*, 2021; Bhanu *et al.*, 2025). Herbal wines are produced by incorporating extracts from medicinal plants, primarily herbs such as amla, ginger and basil and have gained popularity for their therapeutic qualities, including antimicrobial, anticancer and digestive benefits (Morya *et al.*, 2024; Rathi, 2018).

Turmeric (*Curcuma longa*), a revered medicinal herb recognized for its high curcuminoid content, especially curcumin, is known for its strong antioxidant, anti-inflammatory and antimicrobial properties (Mane *et al.*, 2018; Hamad *et al.*, 2025). Traditionally used in Indian medicine, turmeric shows positive effects in treating cancer, infections, diabetes and liver issues (Gupta *et al.*, 2012).

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How to cite this article: Vahini, R.V., Nilaa, M.K.O. and Shri, K.T. (2025). A Study on Formulation and Evaluation of Phytochemicals, Polyphenols and Antioxidants Activity of Herbal Grape Wine Incorporated with Fresh Turmeric Rhizome (*Curcuma longa*). *Asian Journal of Dairy and Food Research*. 1-6. doi: 10.18805/ajdfr.DR-2388.

Submitted: 05-08-2025 **Accepted:** 30-09-2025 **Online:** 21-10-2025

In recent years, the application of turmeric rhizome has expanded worldwide, showing a growing interest in novel food products by health-conscious consumers (Guerra *et al.*, 2020; Maji *et al.*, 2018). However, its limited absorption in the body is a challenge that can be overcome by formulating fermented products incorporated with turmeric rhizome (Sharifi-Rad *et al.*, 2020). Incorporation of turmeric into grape wine offers a novel avenue to develop a herbal-functional beverage with synergistic health benefits derived

from both turmeric and grapes. Despite turmeric's known health benefits, its low bioavailability limits its use in food and beverages. This study aimed to develop a functional herbal wine by incorporating fresh turmeric rhizome, both as diced turmeric and extract, into grape wine and to evaluate its functional properties.

MATERIALS AND METHODS

The formulated herbal grape wine infused with fresh turmeric rhizome in two different ways was analyzed for its various functional properties. This present investigation has been approved by the Independent Human Ethics Committee (IHEC) dated 07/10/2024 (Protocol no SDNBVC/HSE/IHEC/2024/29) and the study was conducted in the Postgraduate Department of Home Science - Food Science, Nutrition and Dietetics, Shrimathi Devkunvar Nanalal Bhatt Vaishnav College for Women, Chennai, Tamil Nadu in the year 2024.

Procurement of ingredients

The fresh turmeric rhizome was bought from the local market in Chennai. The turmeric rhizome was authenticated by the Siddha Central Research Institute, Ministry of AYUSH and Government of India (Code: C09122403L). The other raw ingredients, such as grapes and table sugar, were purchased from a local supermarket in Chennai, Tamil Nadu. *Saccharomyces cerevisiae* yeast strain (MTCC 4781) used for wine preparation was purchased from the Microbial Type Culture Collection and Gene Bank (MTCC), Chandigarh.

Preparation of yeast culture

The culturing of the yeast strain was done following the method demonstrated by Ball *et al.* (2017). Freeze-dried *Saccharomyces cerevisiae* was rehydrated in YP5D or YPD medium and incubated at 30°C. Sonication was applied as needed to disperse spore clumps and growth was monitored via optical density and biomass. Vegetative cells were rehydrated in phosphate buffer and plated to assess viability. Sterile conditions and proper aeration were maintained throughout for optimal recovery and proliferation.

Formulation of herbal grape wine incorporated with fresh turmeric rhizome

Standard vinification procedure was carried out according to the methods suggested by Chawafambira, (2021), with slight modifications. After preliminary cleaning and preprocessing steps, two wine variants was prepared infusing diced turmeric rhizome (W-DTR) and turmeric rhizome extract (W-TRE) followed by 15 days of fermentation at optimum fermentation temperature of 23°C and inoculum concentration of 5% (v/v) (*Saccharomyces cerevisiae*) and turmeric extract and diced turmeric concentration of 10% (v/v). The fermentation procedure was carried out in a pre-sterilized glass jar sealed with muslin cloth. After 15 days of fermentation, the herbal wine was

filtered using sterilized muslin cloth and stored in 500 mL sterilized glass bottles for maturation.

Functional analysis of the formulated herbal grape wine incorporated with fresh turmeric rhizome

The functional properties of the wine samples were evaluated employing standardized AOAC procedures. The radical scavenging activity was determined by the AOAC method (2023) employing the DPPH radical scavenging assay. The qualitative phytochemical screening was performed based on the method described by Mahapatra *et al.* (2023), using standard tests to detect the presence of flavonoids, tannins, phenols, glycosides, terpenoids, alkaloids, saponins and steroids. The total phenolic content was measured using the Folin-ciocalteu and the results were expressed in terms of gallic acid equivalents (GAE) and the Total flavonoid content was quantified using a colorimetric assay, following the procedure described in the study (Kumaresan *et al.*, 2024; Gomez *et al.*, 2022). Resveratrol content was determined using high-performance liquid chromatography (HPLC) according to the method described by Camont *et al.* (2009). In contrast, curcumin content was assessed using a UV spectrophotometric technique as outlined in the research (Kadam *et al.*, 2013).

Statistical analysis

Statistical analysis was carried out using SPSS Software (version 20.0 for Windows, Chicago, IL, USA). All the experiments are performed in triplicate and expressed as mean $\pm$ SD. Analysis of Variance (ANOVA) was performed to validate the study data at 5% level of significance and the Duncan multiple range test was employed to compare the means (DMRT).

RESULTS AND DISCUSSION

Qualitative phytochemical screening of the formulated herbal wine

Phytochemicals are bioactive compounds naturally found in plants, known for their potential health-enhancing properties. Herbal wines, especially those containing grapes and turmeric, are rich in diverse phytochemicals such as flavonoids, phenols and tannins. Table 1 demonstrates the result of the Qualitative analysis of T1 (W-DTR) and T2 (W-TRE), which is compared with the control sample.

The results confirmed the presence of flavonoids, tannins, phenols, terpenoids and glycosides in all three samples - control, T1 (W-DTR) and T2 (W-TRE), which is consistent with the findings of the previous study (Tia *et al.*, 2025). Flavonoid levels were notably elevated in both T1 and T2 compared to the control. The detection of these bioactive compounds aligns with findings reported by Mahapatra *et al.* (2023) in ginger wine by Grover *et al.* (2021) in turmeric extract. Their presence suggests a synergistic contribution from both grapes and turmeric extract and

potentially enhancing the wine's nutritional composition. Phytochemicals such as flavonoids and tannins are known for their antioxidant, anti-inflammatory and antimicrobial properties, supporting therapeutic effects including cancer prevention and neuroprotection (Ullah *et al.*, 2020).

Polyphenolic content of the formulated herbal wine

Polyphenols are a diverse group of plant-based compounds known for their strong antioxidant properties and health-promoting effects. In general, grapes are naturally rich in polyphenols such as flavonoids, tannins and resveratrol and infusion of turmeric (*Curcuma longa*), a rich source of curcuminoids, is expected to further enhance the polyphenolic profile of the wine. Therefore, the formulated wine was assessed for total phenolic content (TPC), total flavonoid content (TFC), resveratrol content and curcumin levels and represented in Table 2.

Total phenolic content

The total phenolic content of the control, T1 (W-DTR) and T2 (W-TRE) has statistically significant differences. The control wine had a low value of 5.9/ mg GAE/g, whereas T1 (W-DTR) and T2 (W-TRE) samples had higher total phenolic content (109.31/ mg GAE/g and 108.29/ mg GAE/g). This indicates that the formulation of herbal grape wine with fresh turmeric leads to an enhancement in phenolic content due to the presence of curcuminoids and other phenolic constituents from the rhizome. This observation is consistent with the findings of the study by Yuwa-

Amornpitak *et al.* (2012), who reported that herbal wine derived from cassava starch exhibited higher phenolic levels compared to conventional wines. According to the study (Stratil *et al.*, 2008), these phenolic compounds contribute significantly to antioxidant activity, although some may diminish over time due to interactions with yeast and protein molecules.

Total flavonoid content

The total flavonoid content (TFC) of the control, T1 (W-DTR) and T2 (W-TRE) has statistically significant differences ($p < 0.05$). The total flavonoid content of the formulated herbal grape wine incorporated with turmeric was found to be 23.25/ mg QCE/g in T1 (W-DTR) and 29.09/ mg QCE/g in T2 (W-TRE), which is much higher when compared to the TFC of the control sample (0.318/ mg QCE/g). As expected, infusion of fresh turmeric rhizome significantly influenced the flavonoid profile of the formulated wine samples. The flavonoid levels observed exceeded typical red wine values (0.014-0.310/ mg QCE/g) (Hosu *et al.*, 2014), likely due to the synergistic effect of quercetin from grapes and curcumin from turmeric, enhancing bioavailability (Ledda *et al.*, 2010; Sharifi-Rad *et al.*, 2020). These results support the use of turmeric as a potent phytochemical enriching agent in herbal wine production.

Total resveratrol content

The Total Resveratrol content of the control, T1 (W-DTR) and T2 (W-TRE) exhibited statistically significant differences

Table 1: Qualitative phytochemical screening.

Phytochemicals	Control	T1 (W-DTR)	T2 (W-TRE)
Flavonoid	+	++	++
Alkaloid	-	-	-
Saponin	-	-	-
Tannin	+	+	+
Phenol	+	+	+
Terpenoid	+	+	+
Steroid	-	-	-
Glycoside	+	+	+

+ Low presence, ++ Moderate presence, +++ High presence.

Treatment 1 - Herbal grape wine incorporated with diced turmeric rhizome (W-DTR), Treatment 2 - Herbal grape wine incorporated with turmeric rhizome extract (W-TRE).

Table 2: Functional properties.

Properties	Control	T1 (W-DTR)	T2 (W-TRE)	<i>p</i> -value
Total phenolic content (mg GAE/g)	5.9 ^a ±0.05	109.31 ^c ±0.19	108.29 ^b ±0.34	$p < 0.05$
Total Flavonoid content (mg QCE/g)	0.318 ^a ±0.05	23.25 ^b ±1.51	29.09 ^c ±0.92	$p < 0.05$
Total Resveratrol content (mg/dm ³)	10.9 ^a ±0.5	17.51 ^c ±1.2	13.07 ^b ±0.8	$p < 0.05$

All the data are expressed as the means of triplicate determinations ± standard deviation, significantly different ($p < 0.05$) by ANOVA. The same superscripts in the row indicate the same to each other and different superscripts in the row indicate different to each other are significantly ($p < 0.05$) based on Duncan's Multiple Range Test (DMRT).

Treatment 1 - Herbal grape wine incorporated with diced turmeric rhizome (W-DTR), Treatment 2 - Herbal grape wine incorporated with turmeric rhizome extract (W-TRE).

($p < 0.05$). The total resveratrol content of the control was found to be 10.9 mg/dm^3 , whereas the treatment sample contained 17.51 mg/dm^3 in T1 (W-DTR) and 13.07 mg/dm^3 in T2 (W-TRE). The formulated herbal grape wine enriched with turmeric rhizome exhibited a high resveratrol content, exceeding the typical levels found in red wines, which range from 6.9 to 12.6 mg/dm^3 (Balanov *et al.*, 2021) depending on grape variety, fermentation duration and extraction procedure. The presence of curcumin may contribute to improved extractability or stability of resveratrol, aligning with the findings of Lund *et al.* (2014), who reported enhanced bioavailability when polyphenols are combined. Furthermore, the presence of turmeric in the wine matrix possibly aids in protecting resveratrol from oxidative degradation (Mattivi *et al.*, 1995).

Total curcumin content

The total curcumin content of the formulated herbal grape wine was analyzed to assess the contribution of turmeric-derived bioactive compounds to the wine's overall functional potential. Also, the total curcumin content of the control sample is not evaluated as the turmeric is not added in the control sample. Table 3 represents the total curcumin content of the formulated herbal wine.

The total curcumin content in T1 (W-DTR) and T2 (W-TRE) was monitored over a 15-day fermentation period at 5-day intervals. A steady increase in curcumin levels was observed throughout the fermentation, with statistically significant differences between the two treatments at all three time points. T1 (W-DTR) increased from 34.44 mg/g on day 5 to 61.06 mg/g by day 15, while T2 (W-TRE) consistently showed higher levels from 45.45 mg/g to 66.02 mg/g . According to Salve *et al.* (2023), the increase is likely due

to enzymatic activity from *S. cerevisiae*, enhancing curcumin release. T2 (W-TRE) higher levels may result from better solubility and extractability of the turmeric extract. These findings align with Lund *et al.* (2014), who noted enhanced curcumin bioavailability when combined with resveratrol and quercetin. Compared to turmeric-enriched bread, which contains 2.65 mg/g curcumin (Lim *et al.*, 2011), the wines demonstrate significantly greater curcumin content, supporting their potential health benefits.

Antioxidant activity of the formulated herbal wine

Herbal wines are known to exhibit strong antioxidant activity due to the presence of bioactive phytochemicals with free radical scavenging properties. The antioxidant activity of the formulated herbal grape wines was evaluated using DPPH radical scavenging and the results are presented in Table 4.

The antioxidant activity of both wines (T1 and T2) exhibited considerable free radical scavenging activity. Notably, T2 (W-TRE), with incorporated turmeric rhizome extract, consistently outperformed T1 (W-DTR) across all tested concentrations. At $1000 \text{ } \mu\text{g/mL}$, T2 achieved 86.64% activity when compared to the antioxidant activity of T1 (79.00%). Furthermore, at $500 \text{ } \mu\text{g/mL}$, T2 surpassed even the standard ascorbic acid (78.57% vs. 74.18%), indicating a high antioxidant potential. These findings suggest that the infusion of turmeric extract enhances the functional efficacy of the wine, possibly due to increased polyphenol content and better bioavailability of bioactive compounds, as also noted in previous studies (Cendrowski *et al.*, 2021). Similar findings were reported by Sharma *et al.* (2020), where almond peel wine fortified with boiled ginger showed higher antioxidant activity than unfortified and commercial

Table 3: Total curcumin content.

Day	T 1 (W-DTR) (CE mg/g)	T2 (W-TRE) (CE mg/g)	p-value
Day 5	$34.44^a \pm 0.496$	$45.45^b \pm 1.61$	$p < 0.05$
Day 10	$44.44^a \pm 1.48$	$57.70^b \pm 1.38$	$p < 0.05$
Day 15	$61.056^a \pm 0.206$	$66.022^b \pm 0.43$	$p < 0.05$

All the data are expressed as the means of triplicate determinations $\pm$ standard deviation, significantly different ($p < 0.05$) by ANOVA. The same superscripts in the row indicate the same to each other and different superscripts in the row indicate different to each other are significantly ($p < 0.05$) based on Duncan's Multiple Range Test (DMRT).

Treatment 1 - Herbal grape wine incorporated with diced turmeric rhizome (W-DTR), Treatment 2 - Herbal grape wine incorporated with turmeric rhizome extract (W-TRE).

Table 4: Antioxidant activity.

Concentration ($\mu\text{g/mL}$)	Standard (Ascorbic acid)	T1 (W-DTR) (%)	T2 (W-TRE) (%)
IC_{50}	66.34	121.71	105.27
50	42.49	39.69	39.85
100	53.32	48.63	49.61
250	62.85	60.85	59.81
500	74.18	70.71	78.57
1000	91.81	79.00	86.64

Treatment 1 - Herbal grape wine incorporated with diced turmeric rhizome (W-DTR), Treatment 2 - Herbal grape wine incorporated with turmeric rhizome extract (W-TRE).

wines. Patel *et al.* (2022) confirmed that herbal extracts enhance radical scavenging activity, boosting the nutritional and functional value of wines.

CONCLUSION

This present study investigated the potential of infusing fresh turmeric rhizome extracts and freshly diced turmeric rhizome into grape wine and evaluated its functional properties. The functional properties of both T1 and T2 demonstrated notable bioactivity; however, T2 consistently outperformed T1 across multiple parameters. T2 showed significantly higher total phenolic and flavonoid contents, enhanced phytochemical properties and greater antioxidant activity throughout the fermentation period. Additionally, the wine formulated with turmeric extract exhibited substantially higher curcumin content, likely due to improved extractability and bioavailability of turmeric compounds in the extract form. Overall, the results highlight turmeric's potential to enrich the nutritional and functional quality of grape wine, with turmeric extract proving to be the more effective and beneficial form for developing functional herbal wines. Given curcumin's extensively studied antioxidant and bioactive properties, this study supports its growing application in novel food product development and expands the prospects of turmeric-enriched wine as a value-added product with nutraceutical potential. The effective combination of turmeric's curcumin and grape's resveratrol resulted in a synergistic improvement in the functional properties of the formulated herbal wine incorporated with turmeric.

ACKNOWLEDGEMENT

I sincerely thank the management of SDNB Vaishnav College for Women (Autonomous), Chromepet, Chennai, for their financial support under the Young Research Project (YRP) and encouragement.

Conflict of interest

The author(s) do not have any conflict of interest.

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