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Impact of coconut water and grape juice blend on physico-chemical and sensory properties of wine

Nabin KHADKA [1], Manita CHAUDHARY [2], Ganga SANGROULA 1*, Aayusha REGMI [2], Sabin Bahadur KHATRI [1], Navin GAUTAM [1]

[1] Department of Food Technology, Tribhuvan University, Central Campus of Technology, Dharan, Sunsari-Nepal
[2] Department of Food Technology, Tribhuvan University, Nilgiri College, Itahari, Sunsari-Nepal

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* CONTACT

samyogsangroula511@gmail.com

ABSTRACT

This study focused on crafting a unique wine by blending grape juice with coconut water (CW) in varying ratios (1:2, 2:2, and 2:1), supplemented with crystallized refined table sugar to maintain a 15 ^{o}Brix. Fermentation, initiated with the wine yeast S. Cerevisiae VR21, at 0.2 g/100 mL of must, occurred at room temperature. Daily monitoring of physio-chemical parameters [total soluble solids (TSS), pH, and acidity] provided insights into substrate utilization kinetics and fermentation dynamics. The chemical constituent analysis examined the impact of grape juice concentration on the CW wine's chemical properties. During the period of fermentation, the findings indicated significant changes in must constituents; pH was found to be decreased, TSS was decreased and attained steady state however, acidity continuously rose. Subsequently, a sensory analysis using GenStat software version 12.1 evaluated the formulated samples' appearance/color, aroma, taste/body, and overall acceptability. Sensory analysis revealed a preference for formulations with CW and grape juice concentration ratios of 2:2 and 1:2. Particularly, within these ratios, a formulation with a higher proportion of grape juice exhibited superior concentrations of aldehyde, total phenolic content, and antioxidant activity, suggesting enhanced overall quality. This research provides a comprehensive understanding of the chemical and sensory aspects of these distinctive coconut water wine blends.

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1. Introduction

Winemaking is a centuries-old technology that has become a highly profitable biotechnology process (Chakraborty et al., 2014). Since the beginning of civilization, the process of creating wine has been known and has developed with agricultural and human advancement (Chambers and Pretorius, 2010). A variety of raw materials have been used to make wine, either to add flavor or to add important chemical components (Gubhaju, 2006). Wine is a low-alcohol beverage produced by partially or fully fermenting fresh grapes or grape juice (He et al., 2023). Furthermore, wine includes a variety of nutrients that the human body needs, including sugar, vitamins, amino acids, mineral elements, and polyphenols. These nutrients are mixed with alcohol, organic acids, and fragrance components to provide the wine with a more distinct sensory flavor and a better nutritional value (Fia et al., 2018).

Coconut (*Cocos nucifera* L.) is a monoecious perennial palm belonging to the Arecaceae family (Niral and Jerard, 2019). Coconuts are tropical fruits originating from Southeast Asia and are extensively grown in tropical Africa and Latin America (Foale et al., 2020). More than 80% of the world's coconuts are produced in the Asian-Pacific region (Samosir et al., 2006). With their significant export value and influence on local economies and cultures, coconuts are among the most crucial sources of revenue for many of the countries in this region (Samosir et al., 2006). Coconut water (CW), or liquid endosperm, makes up around 25% of the total weight of the nut. Moreover, the drink has a somewhat sweet and acidic flavor (pH 5.6), and the clear liquid within young green nuts comprises around 5% total solids by weight (Purkayastha et al., 2012).

CW nutritional value varies depending on age, type, location, soil condition, and environmental conditions (Chourio et al., 2018). CW, derived from young green coconuts, is a natural and nutritious beverage rich in minerals, sugars, proteins, and vitamins (Sunil et al., 2020). It includes minerals, amino acids, phytohormones, and helpful bioactive components, such as vitamin C, vitamin B, potassium, calcium, magnesium, sodium, glutamic acid, lysine, arginine, alanine, cytokinin, and others (Matsui et al., 2008; Rethinam and Krishnakumar, 2022; Yong et al., 2009). Furthermore, CW is utilized for various food products like tender coconut water, snowball tender nut, vinegar, etc. for its various health benefits, which include boosting the immune system, detoxification, curing hangovers, etc. (Emojevwe, 2013).

Due to its improved flavor, natural hydration characteristics, functional health benefits, and nutritional advantages, CW consumption is now rising globally and is among the beverage categories with the greatest rate of growth (Campbell-Falck et al., 2000; DebMandal and Mandal, 2011). Once the water is withdrawn or separated from the inner cavity, it degrades rapidly. Additionally, spoilage is primarily caused by microbiological activity, physical impurities, storage conditions, and the types of packing materials applied (Ciou et al., 2011) Green coconut water is highly susceptible to oxidation by native enzymes like peroxidase and polyphenol oxidase, which causes nutritional and color losses (Matsui et al., 2008). Globally, about 14% of produced coconut is lost Shahbandeh (2023). Lindner et al. (2013) state that fermented foods are becoming more widely accepted due to their practical advantages. Thus, the fermentation of the green coconut water could be the best way of preserving it, which is rarely studied. CW only contains 5-6% soluble solids, so for the fermentation study, the addition of fresh grape juice is suggested by Satheesh and Prasad (2013). The main objective of the research work is to study the effect of grape juice and coconut water blends on the production of coconut water-based fermented beverages.

2. Materials and methods

2.1. Description of study area

The research was performed from June 2023 to July 2023 in the research lab of Nilgiri College Itahari, Sunsari, Nepal. Geographically, the experimental area is situated at Latitude 26º 40′ 0.01″ N, and Longitude 87º 16′ 59.99″ E with an average altitude of 117.63 m (385.93 ft.). The minimum and maximum temperatures range from 10 and 42 ^{o}C respectively, and the average annual precipitation falls up to 2007 mm.

2.2. Raw materials

Coconut water processed and packaged by Tipco F & B, Ltd., Thailand, was purchased from the supermarket in Itahari, a sub-metropolitan city. CW was claimed to be free from any type of contaminants, and there were no added sugars or preservatives. Matured, fresh, and sound-quality purple grapes were purchased from the local market in Itahari. Crystallized refined cane sugar was obtained from sugarcane juice, purchased from the local market in Itahari, and commercial wine yeast, Saccharomyces cerevisiae VR 21, was taken from the lab of Nilgiri College, Itahari, Sunsari, and applied for attenuation and fermentation, respectively.

2.3. Experimental method

All the raw materials were collected. The grapes were first sorted, the stem removed, and then washed with potable water. Then the whole grapes were crushed gently and ground in an electric grinder to extract the juice. The crushed grapes were subjected to straining on a clean muslin cloth. Gentle hand pressing was done to extract clear grape juice. Thus, the obtained juice was blended with CW in three different proportions: 1:2, 1:1, and 2:1 by volume and coded as samples A, B, and C respectively. The total soluble solid content of the must was adjusted to 15-degree brix (°Bx) with pulverized table sugar and then transferred to the amber-colored glass bottle for fermentation. The experiments were conducted in triplicate for each blend. A pure yeast culture at a rate of 0.2 g/100 mL (Boulton et al., 1998) must be inoculated, no artificial preservatives were added and allowed to ferment at the temperature of 28 ºC until a constant total soluble solid was obtained. When the constant TSS was observed the fermentation was indicated to be completed after 5 days, the wine was racked into amber-colored glass bottles and then pasteurized at 68 °C for 5 minutes. The prepared wine was then stored at a refrigerated temperature (at 4 °C) and then subjected to sensory analysis. During the fermentation, total soluble solids, pH, and acidity were analyzed daily.

2.4. Analytical methods

2.4.1. Total soluble solids and pH

The pH and Total soluble solid (TSS) was determined by the method given by FSSAI (2021).

2.4.2. Total acidity

Using phenolphthalein indicators, a 10 mL sample was pipetted out and titrated with 0.1 N NaOH. The total acidity was determined by the titrimetric method as per AOAC (2005).

Total acidity (tartaric acid) (g/L of wine) = (V X 0.00375 X 1000) / V_1.

Where,

V_1 is the volume of wine taken

V is the volume of standard NaOH used for titration in mL

Note: 1 mL of 0.05N is equivalent to 0.00375 g

2.4.3. Volatile acidity

For volatile acidity determination, 50 mL of distillate that was collected during the determination of ethyl alcohol was titrated against standard NaOH using the phenolphthalein indicator (FSSAI, 2021).

$$\text{Volatile acidity as acetic acid (g/L)} = \frac{V \times 0.003 \times 1000}{V_1}$$

Where,

V_1 is the volume of sample taken (mL)

V is the volume of standard NaOH used for titration (mL)

Note: 1 mL of 0.05N NaOH is equivalent to 0.003 g of acetic acid

2.4.4. Alcohol content

The alcohol concentration was assessed using the specific gravity technique as described in FSSAI (2021). For the identification, 200 mL of sample was taken in a distillation flask with 50 mL of distilled water. The content was then distilled to collect 200 mL of distillate. The distillate was gently poured into a specific gravity bottle maintained at a temperature of 20 ℃. Finally, specific gravity was determined, and the alcohol content was obtained from the standard specific gravity vs. alcohol content chart.

2.4.5. Ester

The ester contents of samples were determined as per the method described by the FSSAI (2021). Briefly, 200 mL of the sample was used for distillation, and 50 mL of distillate was recovered, and neutralized with 0.1 N NaOH, an addition of 5 mL of 0.1 N NaOH, and refluxed for one hour. Then, the cooling and back titration of unspent alkali against 0.1N sulfuric acid were carried out. Blank titration was carried out simultaneously with 50 mL of distilled water. The difference in titer value in milliliters of standard sulfuric acid gave an equivalent ester. The values were expressed in grams per 100 liters of ethyl alcohol as ethyl acetate.

$$\text{Ester as ethyl acetate (g/100L abs. alcohol)} = \frac{V \times 0.0088 \times 100 \times 1000 \times 2}{V_1}$$

Where,

V is the difference of the titer value of std. H_2SO_4 used for blank and sample (mL)

V_1 is the alcohol by volume (%abv)

Note: 1 mL of 0.1 N NaOH is equivalent to 0.0088 g of ethyl alcohol

2.4.6. Aldehyde

After keeping the flask containing 50 mL of distilled liquor and 10 mL of bisulfate solution for 30 min, the addition of 25 mL of standard iodine solution was performed, then back titration against the standard thiosulphate solution using a starch indicator to the light green endpoint was performed. (FSSAI, 2012). Similarly, a blank was performed using 50 mL of pure water, Then, analogous aldehyde content was calculated by applying the difference in titer value in milliliters of sodium thiosulfate solution (FSSAI, 2012).

$$\text{Aldehyde as acetaldehyde (g/100L abs. alcohol} = \frac{V \times 0.0011 \times 100 \times 1000 \times 2}{V_1}$$

Where,

V_1 is the alcohol by volume (%abv)

V is the difference in titer of the blank and sample (mL) of sodium thiosulfate solution

Note: 1 mL of 0.05 N sodium thiosulfate corresponds to 0.0011 g acetaldehyde.

2.4.7. Higher alcohol

The higher alcohol content in the wine samples was determined by the titrimetric method as described in FSSAI (2021). For the determination of higher alcohol, a solution obtained from the determination of esters was mixed with 50 mL of distilled water. Sodium chloride was added for extraction up to four times, with progressively larger portions of carbon tetrachloride (40, 30, 20, and 10 mL each). Then, the extract was filtered after washing three times with a saturated sodium sulfate solution, and 50 mL of the oxidizing mixture was added, which was refluxed for two hours. After reflux, it was transferred to the distillation assembly using 50 mL of water. About 100 mL of distillate was titrated against NaOH using a phenolphthalein indicator. Likewise, blank was run, and higher alcohol was determined.

$$\text{Higher alcohol as amyl alcohol (g/L absolute alcohol)} = \frac{V \times 0.0088 \times 100 \times 1000 \times 2}{V_1 \times V_2}$$

Where,

V is the difference in titer

V_1 is the volume of the sample

V_2 is alcohol % (v/v)

2.4.8. Methanol

To begin with, 500 milliliters of wine were taken, and 50 milliliters of distillate were obtained. The distillate's alcohol concentration was then changed to 5% abv. via the addition of purified water. Next, three separate 50 mL volumetric flasks were filled with 2.0 mL of potassium permanganate solution. One milliliter of each of the chilled samples, standard methanol solution, and the blank solution was added to separate flasks labeled "sample," "standard," and "blank." Afterward, an ice bath was used to immerse all three flasks for thirty minutes. Additionally, each flask was filled with 1.0 mL of chromotopic acid, 15 mL of sulfuric acid, and a small amount of dry $NaHSO_3$. The flasks were then put in a hot water bath for 15 minutes. Following, the cooling of each flask, 50 mL of distilled water was added to the capacity. Using a spectrophotometer, the absorbance of each solution was then measured at 575 nm (FSSAI, 2021).

$$\text{Methanol content (g per 100 L abs. alcohol)} = \frac{A_2 \times C \times D \times 1000 \times 100 \times 100}{A_1 \times S}$$

Where,

A_2 is the absorbance of the sample solution

C is the concentration of methanol standard solution

D is the dilution factor for the sample solution

A_1 is the absorbance of the methanol standard solution

S is the ethanol content (%) of the liquor sample (v/v)

2.4.9. Tannin

For the standard curve, pipetted-out standard tannic acid solutions (0.0, 0.2, 0.4, 0.6, 0.8, and 1.0 mL) were placed in a 100 mL volumetric flask with 75 mL of distilled water. Next, 100 mL of distilled water was added to the mixture after adding 5 mL of Folin-Dennis reagent and 10 mL of sodium carbonate solutions. After thoroughly mixing, the solution was set aside for half an hour. The absorbance of each standard using a reagent blank was determined, and the mg of tannic acid vs. absorbance was plotted for the determination of tannin in wine.

For the determination of tannin in the wine samples, in a 100 mL volumetric flask with 80 mL of distilled water, 1.0 mL of sample wine was pipetted out. Afterward, 10 mL of sodium carbonate solution and 5.0 mL of Folin-Dennis reagent were added, and distilled water was used to bring the volume to 100 mL. Following thorough mixing of the prepared solution, the absorbance was measured against a reagent blank and allowed to stand for 30 min. Finally, mg of tannic acid was obtained using a standard curve, and the calculation was done to express the value in g per liter of wine (FSSAI, 2021).

2.4.10. Total phenolic contents

Total phenolics was determined by the Folin-Ciocalteu method as mentioned by Stratil et al. (2008) with a slight modification. At first, 20, 40, 60, 80, and 100 ppm of a standard gallic acid solution were prepared. The absorbances of all standard solutions were noted at the 760 nm wavelength. The absorbance vs. gallic acid concentrations were linearly plotted. Aliquots of 300 microliters were combined with 1.5 mL of diluted Folin-Ciocalteau's reagent (10 times) and 1.2 mL of 7.5% sodium carbonate in a test tube containing the appropriately diluted samples.

2.4.11. Antioxidant activity

The antioxidant activity, expressed as free radical scavenging activity (RSA), in the prepared wine, was determined by the diphenyl-p-picrylhydrazyl (DPPH) method, as mentioned by Hwang and Lee (2023). In summary, the sample (100 µL), methanol (4.4 mL), and DPPH radical methanol solution (0.5 mL, 1 mmol/L) were combined for 15 seconds and allowed to react at room temperature for 30 min. Using a spectrophotometer single-beam UV-visible spectrophotometer using a quartz cuvette, the mixture's absorbance was determined at 517 nm. Using gallic acid, a standard curve for the standard compound's concentration and the rate at which DPPH radicals are scavenged was drawn. In milligrams of gallic acid equivalents per liter of wine, the sample's DPPH radical scavenging activity was reported.

2.5. Sensory evaluation

To ensure customer acceptance, obtained beverages underwent a sensory examination. Clean wine glasses with silent surroundings were used to offer the samples. Nine points were used to rate the sensory qualities (color/appearance, scent, taste, and overall acceptability). A hedonic scale rating test with ten semi-trained panelists, including instructors and students, ranging from dislike highly (1) to like exceedingly (9) of Nilgiri College, those who were familiar with alcoholic beverages. They assessed the beverages in terms of organoleptic parameters.

2.6. Statistical evaluation

A statistical application called GenStat version 12.1 was used to evaluate all of the data collected for the research work. Using an ANOVA, the mean and Tukey HSD at the 5% level of significance were calculated. Additionally, MS Excel was used to create the general diagram and graph.

3. Result and discussion

3.1. Chemical constituents of coconut water and grape juice

The general constituents of coconut water (CW) and grape juice were determined and tabulated in Table 1. The constituents of CW were in the range mentioned by Shayanthavi et al. (2024) and the content was claimed to be free from any added sugar, preservatives, fat, and cholesterol. Researchers concluded that various factors might affect the constituents of CW. Factors noted are the age of the coconut, variety of coconut, climatic conditions, etc. (Tan et al., 2014; Adubofour et al., 2016; Halim et al., 2018; Shayanthavi et al., 2024). The values obtained were compared with those of Sousa et al. (2014) and were in the range. Climate, storage temperature and condition, and juice extraction mechanisms are the factors that might affect the constituent composition of grape juice (Umar et al., 2022).

Table 1. General constituent of coconut water (CW) and grape juice

Parameters	Coconut water	Grape juice
pH	5.1 ± 0.0058	3.29 ± 0.01
TSS (°Bx)	5.2 ± 0	13 ± 0
Acidity (%)	0.0898 ± 0.0023 (as malic acid)	0.21 ±0.003 (as tartaric acid)
Reducing sugar (% dextrose equivalent)	2.32 ± 0.54	0.1812 ± 0.015
Ash content (%)	0.365 ± 0.00058	0.898 ± 0.05

Note: values are the mean of triplicate and ± represents the standard deviation of the values.

3.2. Changes in TSS, pH, and acidity during fermentation

Changes in total soluble solids, pH, and acidity during the course of fermentation for five days are shown in Table 2. According to the statistical study, the components significantly changed during the fermentation process. All three samples with grape juice (GJ): CW proportions: 1:2, 1:1, and 2:1 by volume and coded as samples A, B, and, C respectively, show a similar pattern of changes during storage. The rate of changes might be altered due to the compositional variations in the fermenting must due to the blend. Soares et al. (2016) studied the changes during the fermentation of CW wine by adjusting TSS to 15 °Brix with table sugar and observed a similar pattern in soluble solids change.

They observed an 11% depletion of soluble solids in 30 days of fermentation. The rate of change in TSS might be different due to the fact that they use 100 ppm of SO_2 and the difference in temperature. Total sugar drops steadily, while reducing sugar increases constantly until the first 3 days but quickly decreases thereafter (Xia et al., 2011). The rapid depletion in TSS and pH was reported by Lee et al. (2013) while CW was subjected to fermentation at 28 °C for 2 days. The depletion of soluble solids indicates the corresponding production of ethanol, organic acids, and other volatiles, which ultimately increase the total titratable acidity, and reduce pH. Satheesh and Prasad (2013), reported that a CW and grape juice blend results in a higher percentage of constituents compared with coconut water wine.

Table 2. Changes in TSS, pH and acidity during the course of fermentation

Parameters	Samples	Fermentation time (days)					
		0	1	2	3	4	5
TSS (°Brix)	A	15 (0)ᵃ	12.033 (0.057)ᵃ	9.033 (0.057)ᶜ	6.067 (0.057)ᵇ	5.367 (0.057)ᵃ	5 (0)ᵃ
	B	15 (0)ᵃ	13.033 (0.057)ᵇ	8.1 (0.1)ᵇ	6 (0)ᵇ	5.4 (0.057)ᵃ	5 (0)ᵃ
	C	15 (0)ᵃ	12.033 (0.057)ᵃ	7.033 (0.057)ᵃ	5.033 (0.057)ᵃ	5.367 (0.057)ᵃ	5 (0)ᵃ
	Mean	15	12.36	8.056	5.7	5.4	5.0
	SEM (±)	-	0.047	0.06	0.038	0.04	-
	CV (%)	-	0.5	0.9	0.8	1.1	-
	LSD	-	0.11	0.14	0.094	0.11	-
	F-Test	NS	***	***	***	NS	NS
pH	A	4.56 (0)ᵃ	4.490 (0.026)ᶜ	4.023 (0.068)ᵃ	4.033 (0.057)ᶜ	3.787 (0.321)ᵇ	3.753 (0.080)ᵃ
	B	4.2 (0)ᵃ	4.167 (0.057)ᵇ	3.983 (0.028)ᵃ	3.783 (0.028)ᵇ	3.793 (0.012)ᵇ	3.167 (0.029)ᵃ
	C	4 (0)ᵃ	3.883 (0.029)ᵃ	3.683 (0.029)ᵃ	3.477 (0.040)ᵃ	3.590 (0.017)ᵃ	3.583 (0.029)ᵃ
	Mean	4.25	4.180	4.0	3.76	3.72	3.8
	SEM (±)	-	0.032	-	0.035	0.018	-
	CV (%)	-	1.0	-	1.2	0.6	-
	LSD	-	0.08	-	0.087	0.044	-
	F-Test	NS	***	NS	***	***	NS
Acidity (% as tartaric acid)	A	0.1137 (0.001)ᵃ	0.1203 (0.001)ᵃ	0.1070 (0.0001)ᵃ	0.2417 (0.001)ᵃ	0.1827 (0.0025)ᵃ	0.2133 (0.023)ᵃ
	B	0.1337 (0.0006)ᵇ	0.1393 (0.0006)ᵇ	0.1513 (0.0023)ᵇ	0.2420 (0.0017)ᵃ	0.3147 (0.0254)ᵇ	0.3353 (0.0002)ᵇ
	C	0.1337 (0.0006)ᵇ	0.1517 (0.0011)ᶜ	0.1383 (0.0006)ᶜ	0.3447 (0.008)ᵇ	0.3377 (0.0046)ᵇ	0.4107 (0.0023)ᶜ
	Mean	0.12	0.13	0.13	0.27	0.27	0.32
	SEM (±)	-	-	-	-	0.01	0.01
	CV (%)	0.6	0.7	1.0	1.7	5.4	4.2
	LSD	-	-	-	-	0.02	0.02
	F-Test	***	***	***	***	***	***

Note: Values are the mean of the triplicate and ± indicates the standard deviation of the triplicate data. Mean followed by the same alphabet in the same column signifies no significant difference between the samples, whereas mean followed by a different letter in the same column is significant and tested at the 5% level of significance. Abbreviations: Sample A: one-part GJ and two-part CW, Sample B: equal part of GJ and CW, Sample C: two-part of GJ and one part of CW, LSD: least significant difference, ***Significant at the 0.1% level of significance, NS: Not-Significant.

3.3. Physicochemical properties of samples

The physicochemical properties of the prepared samples are presented in Table 3. Statistical analysis revealed that there was a significant effect of the CW and grape juice blend at a 95% level of confidence. Ester, aldehyde, methyl alcohol, tannin, total phenolic compounds, and antioxidant activity increased significantly when the grape juice proportion was increased. Further addition of sucrose in fermentation must increase the alcohol content and flavor components (H. Liu et al., 2017; J. Liu et al., 2022).

In this experiment, all the samples were adjusted to a total soluble solid of 15 % with a varying blend of CW, grape juice, and sucrose. Grape juice contains a higher amount of coloring pigments, fermentable sugars, and phytochemicals. That might be a reason for the higher contents of the chemical and phytochemical constituents. Aeration of the must, temperature, yeast type, fermentation process, and fruit ripeness are the primary factors that determine the chemical composition of wine (Buglass, 2011). Depending on the nature of the must, the ester content in wines ranges widely from 25 mg/L to 300 mg/L, the ester content of all three samples is within the range revealed by Ronald and Bakker (2004). The aldehyde content was least in sample A increased with an increase in grape juice content in composition samples A and B was within the range as reported by Rai (2009) however, sample C showed higher aldehyde content, which might be due to the chemical constituents of grapes (Buglass, 2011).

The tannin, and phenolic content increases in the composition of grape juice this might be due to the antioxidant activity, polyphenolic compounds, anthocyanins, and other pigments aligned with Yuyuen et al. (2015). The tannin content of all the compositions is within the range as revealed by Harbertson et al. (2008). Pectin content influences the methanol concentration to some extent. Grapes have less pectin than most other fruits. Therefore, out of all fruit-based, fermented beverages, wine has the lowest methanol level (Buglass, 2011). Red wine tends to contain more methanol (between 120 mg/L and 250 mg/L of total wine volume) because of its higher peel content (Hodson et al., 2017). Yuyuen et al. (2015) reported that an increase in the concentration of ripening berries can increase the concentration of tannins and total phenolic content in wine. The increase in tannins and phenolics leads to an increase in antioxidant activity. Phenol content is greatly influenced by a variety of fruits and climatic factors such as soil, exposure to heat, light, and water availability (Eseberri et al., 2022).

Table 3. Chemical properties of the prepared samples

Samples	A	B	C
Ethyl alcohol (ABV)	7.1 ± 0.087[a]	7.97 ± 0.029[b]	7.05 ± 0.087[c]
Esters (mg/L)	192.67 ± 2.52[a]	184.33 ± 3.79[b]	193.18 ± 3.27[a]
Aldehyde (g/100L)	29.19 ± 1.73[a]	40.92 ± 1.46[b]	91.82 ± 1.05[c]
Methyl alcohol (mg/100L)	210.67 ± 1.23[a]	225 ± 2[b]	240.37 ± 1.57[c]
Tannin (mg/L)	37.63 ± 1.24[a]	39.49 ± 0.81[a]	74.89 ± 1.64[b]
Phenolics (mg/L)	2.9 ± 0.025[a]	18.46 ± 0.68[b]	29.32 ± 1.54[c]
Antioxidant activity (mg gallic acid/L)	2.83 ± 0.76[a]	6.6 ± 0.53[b]	11.89 ± 0.93[c]
Higher alcohol (%)	19.68 ± 0[a]	5.05 ± 0[b]	7.38 ± 0[c]

Note: Values are the mean of the triplicate and ± indicate the standard deviation of the triplicate data. Same alphabet in the same row signifies no significant difference between the samples at $p<0.05$, whereas a different letter in the same row signifies a significant difference. **Abbreviations:** Sample A: one-part GJ and two-part CW, Sample B: equal part of GJ and CW, Sample C: two-part of GJ and one part of CW, ABV: Alcohol by volume.

3.4. Sensory analysis of samples

The result of the sensory evaluation of prepared wine samples is presented in Figure 1. Statistical analysis showed a significant effect of formulation on the preference of the panelists towards appearance, aroma, and overall acceptability at the 5% level of significance. According to Yuyuen et al. (2015), ripened berries contain high concentrations of anthocyanins and total phenol contents, as well as higher concentrations of sugar and total red pigments, which results in high color concentration. Thus, panelists favor sample C, which contains two parts of grape juice and only one part of coconut water.

Certain scents found in fermented beverages are esters, which are produced when the alcohol and acids in the beverage react. Esters can form later on through chemical reactions or during fermentation under the influence of yeast. Small amounts of higher alcohol contribute positively to quality, while excessive amounts may detract from quality. So, smell or aroma depends upon the aromatic compounds formed during fermentation and aging (Hazelwood et al., 2008). In the present study, panelists prefer sample C to sample A significantly. That might be due to significantly higher esters and aldehyde content in sample C than in sample A. Panelists do not find a significant effect of the blend on the taste and body of the wine. That might be because there are no significant residual sugar or alcohol levels in the final product. Research has demonstrated that several parameters, including residual sugar in the sample, alcohol concentration, fermentation day, and aromatic components, influence sample flavor (Naknaen et al., 2010).

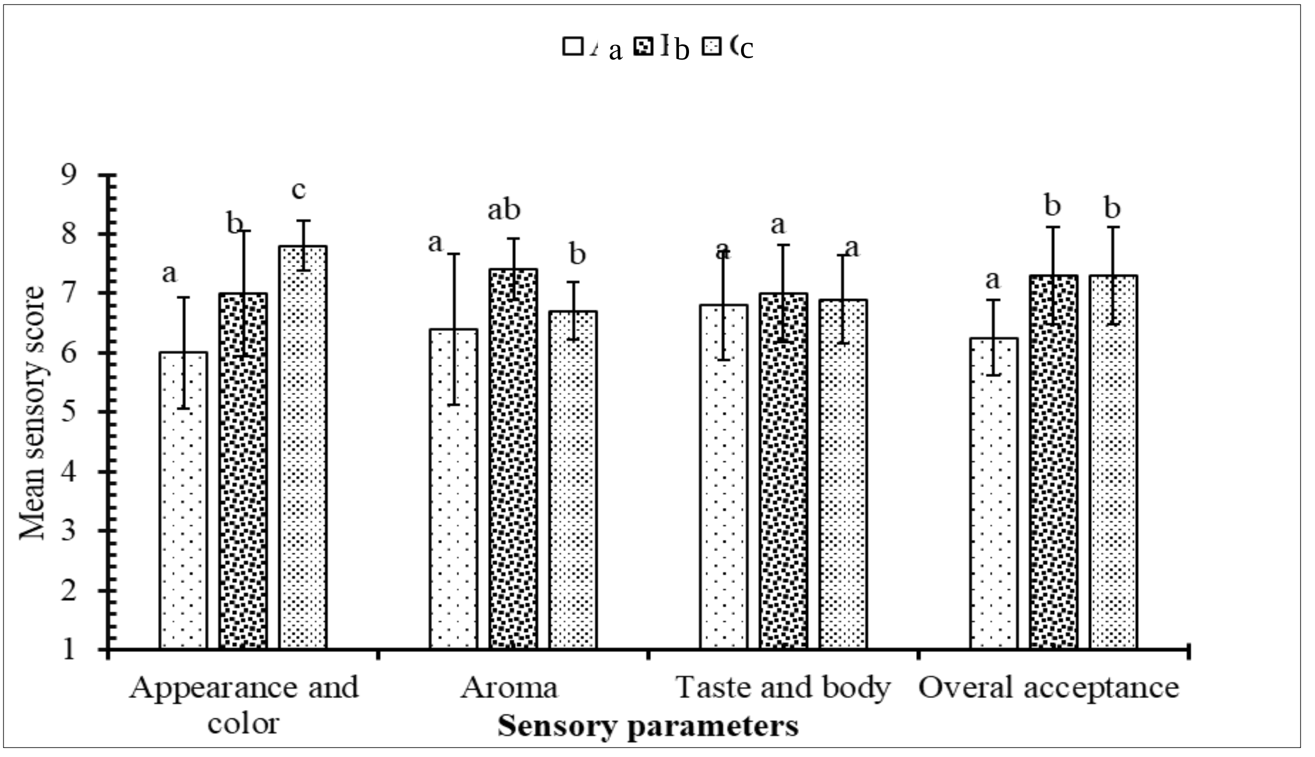

Figure 1. Mean sensory score for the sample parameter. Abbreviations: Sample A: one-part GJ and two-part CW, Sample B: equal part of GJ and CW, Sample C: two-part of GJ and one part of CW. Note: bars represent ± standard deviation of the sensory scores, and the bars with the same alphabets demonstrate that the samples do not significantly vary from one another.

3.5. Selection of best blend composition

Sensory evaluation revealed that there is no significant difference between wine containing the same proportion of grape juice and CW and wine containing double the proportion of grape juice and coconut water in terms of overall acceptability. So, according to color preference and antioxidant content, sample C was taken as the best among the three formulations. An increase in the concentration of grape juice increases the phenolic content, antioxidant activity, color, density, and color index (Poliana et al., 2010). Additionally, Yuyuen et al. (2015) suggest samples containing a higher concentration of grape juice are likely to produce wine with higher acceptance quality.

3.6. Limitations and recommendation

A microbiological analysis of fresh coconut water was not performed during the laboratory work. After the preparation of the wine, it was not adequately matured. To ensure robust conclusions, we recommended further research to be continued by performing microbiological analysis, and maturation of the wine.

4. Conclusions

This study can conclude that grape juice can be blended for the preparation of CW blend wine. The concentration of grape juice has a significant effect on the physicochemical and sensorial characteristics of the wine. An increase in grape juice concentration results in a higher concentration of phytochemical contents. Grape juice blended with CW wine was found to be highly acceptable by the panelists. Two parts of grape juice can be blended with one part of CW for the wine preparation.

Compliance with Ethical Standards

Conflict of interest

The authors declare that they have no conflict of interest.

Authors' contributions

Nabin KHADKA: Conceptualization, Supervision, Methodology, Software, Resources, Validation, Data Curation, Writing- review & editing; **Manita CHAUDHARY**: Methodology, Formal analysis, Resources, Validation, Writing-original draft, Writing- review & editing. **Ganga SANGROULA**: Writing- reviewing & editing, Writing-original draft, Software, Validation, Supervision, Data curation. **Aayusha REGMI**: Software, Resources. **Sabin Bahadur KHATRI**: Software, Resources. **Navin GAUTAM**: Software, Resources.

Ethical approval

The participants in the sensory evaluation voluntarily took part and scored the samples with full satisfaction.

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Data availability

The data underlying this study are available on request from the corresponding author.

Consent for publication

We humbly give consent for this article to be published.

References

Adubofour, J., Amoah, I. & Bonsu, I. O. (2016). Sensory and physicochemical properties of pasteurized coconut water from two varieties of coconut. *Food Science and Quality Management, 54*, 26–32.

AOAC. (2005). "Official Methods of Analysis of Association of Official Analytical Chemists (AOAC)" (18 ed.). AOAC International. [0-935584-75-7].

Boulton, R. B., Singleton, V. L., Bisson, F. L. & Kunkee, R. E. (1998). "Principles and Practices of Winemaking". Aspen Publishers, Inc. Gaithersburg, Merryland. Ch 5, pp 193-243.

Buglass, A. J. (2011). "Handbook of alcoholic beverage: technical, analytical and nutritional aspects". John Wiley and Sons.

Campbell-Falck, D., Thomas, T., Falck, T. M., Tutuo, N. & Clem, K. (2000). The intravenous use of coconut water. *The American journal of emergency medicine, 18* (1), 108-111. https://doi.org/10.1016/S0735-6757(00)90062-7

Chakraborty, K., Saha, J., Raychaudhuri, U. & Chakraborty, R. (2014). Tropical fruit wines: A mini review. *Natural Products, 10* (7), 219-228.

Chambers, P. J. & Pretorius, I. S. (2010). Fermenting knowledge: the history of winemaking, science and yeast research. EMBO. rep. 11 (12), 914-920. https://doi.org/10.1038/embor.2010.179

Chourio, A. M., Salais-Fierro, F., Mehmood, Z., Martinez-Monteagudo, S. I. & Saldaña, M. D. (2018). Inactivation of peroxidase and polyphenoloxidase in coconut water using pressure-assisted thermal processing. *Innovative Food Science & Emerging Technologies, 49*, 41-50.

Ciou, J., Lin, H. H., Chiang, P. Y., Wang, C. C. & Charles, A. L. (2011). The role of polyphenol oxidase and peroxidase in the browning of water caltrop pericarp during heat treatment. *Food Chemistry, 127* (2), 523-527. https://doi.org/10.1016/j.foodchem.2011.01.034

DebMandal, M. & Mandal, S. (2011). Coconut (*Cocos nucifera* L.: Arecaceae): in health promotion and disease prevention. *Asian Pacific Journal Of Tropical Medicine, 4* (3), 241-247. https://doi.org/10.1016/S1995-7645(11)60078-3

Emojevwe, V. (2013). *Cocos nucifera* (coconut) fruit: A review of its medical properties. *Advances in Agriculture, Sciences and Engineering Research, 3*(3), 718-723. https://doi.org/ 10.13140/RG.2.2.21506.53446

Eseberri, I., Trepiana, J., Léniz, A., Gómez-García, I., Carr-Ugarte, H., González, M. & Portillo, M. P. (2022). Variability in the beneficial effects of phenolic compounds: A review. *Nut, 14* (9), 1925. https://doi.org/10.3390/nu14091925

Fia, G., Gori, C., Bucalossi, G., Borghini, F. & Zanoni, B. (2018). A naturally occurring antioxidant complex from unripe grapes: The case of Sangiovese (*Vitis vinifera*). *Antioxidant, 7* (2), 27. https://doi.org/10.3390/antiox7020027

Foale, M., Biddle, J., Bazrafshan, A. & Adkins, S. (2020). Biology, ecology, and evolution of coconut. Coconut Biotechnology: Towards the Sustainability of the 'Tree of Life'. 17-27.

FSSAI, (2021). "Manual for Analysis of Alcoholic Beverages". Food Saftey and Standards Authority of India.

Gubhaju, M. (2006). Preparation and quality evaluation of wine prepared from Rhododendron flower. B. Tech (Food) Dissertation. Central Campus of Technology, Tribhuvan Univ., Nepal.

Halim, H. H., Dee, E. W., Dek, M. S. P., Hamid, A. A., Ngalim, A., Saari, N. & Jaafar, A. H. (2018). Ergogenic attributes of young and mature coconut (*Cocos nucifera* L.) water based on physical properties, sugars and electrolytes contents. *International Journal of Food Properties, 21*(1), 2378-2389. https://doi.org/10.1080/10942912.2018.1522329

Harbertson, J. F., Hodgins, R. E., Thurston, L. N., Schaffer, L. J., Reid, M. S., Landon, J. L., Ross, C. F. & Adams, D. O. (2008). Variability of tannin concentration in red wines. *American Journal of Enology and Viticulture, 59* (2), 210-214.

Hazelwood, L. A., Daran, J. M., Van Maris, A. J., Pronk, J. T., & Dickinson, J. R. (2008). The Ehrlich pathway for fusel alcohol production: a century of research on Saccharomyces cerevisiae metabolism. *Applied and Environmental Microbiology, 74*(8), 2259-2266. https://doi.org/10.1128/AEM.02625-07

He, Y., Wang, X., Li, P., Lv, Y., Nan, H., Wen, L. & Wang, Z. (2023). Research progress of wine aroma components: A critical review. Food Chemistry, 402, 134491. https://doi.org/10.1016/j.foodchem.2022.134491

Hodson, G., Wilkes, E., Azevedo, S. & Battaglene, T. (2017). Methanol in wine. [Report]. Vol. 9. World Congress of Vine and Wine.

Hwang, S. & Lee, J. (2023). Comparison of antioxidant activities expressed as equivalents of standard antioxidant. *Food Science and Technology, 43,* (121522). https://doi.org/10.1590/fst.121522

Lee, P. R., Boo, C. X. & Liu, S. Q. (2013). Fermentation of coconut water by probiotic strains Lactobacillus acidophilus L10 and Lactobacillus casei L26. *Annals of Microbiology, 63*, 1441-1450. https://doi.org/10.1007/s13213-013-0607-z

Lindner, J. D. D., Penna, A. L. B., Demiate, I. M., Yamaguishi, C. T., Prado, M. R. M. & Parada, J. L. (2013). Fermented Foods and Human Health Benefits of Fermented Functional Foods. *Fermentation Processes Engineering in The Food Industry,* 263.

Liu, H., Bao, M. L., Chen, H. L. & Li, Q. (2017). Impact of sucrose addition on the physiochemical properties and volatile compounds of "Shuangyou" red wines. *Journal of Food Quality, 2017*(1), 1-11. https://doi.org/10.1155/2017/2926041

Liu, J., Wang, Q., Weng, L., Zou, L., Huiyan Jiang, H., Qiu, J. & Jiafei Fu, J. (2022). Analysis of sucrose addition on the physicochemical properties of blueberry wine in the main fermentation. *Frontiers in Nutrition, 9,* 1092696.

Matsui, K. N., Gut, J. A. W., de Oliveira, P. V. & Tadini, C. C. (2008). Inactivation kinetics of polyphenol oxidase and peroxidase in green coconut water by microwave processing. *Journal of Food Engineering, 88*, 169-176. https://doi.org/10.1016/j.jfoodeng.2008.02.003

Naknaen, P., Meenune, M. & R., G. (2010). Characterization of palm sap harvested in Songkhla province, Southern Thailand. *International Food Research Journal, 17*, 977-986.

Niral, V. & Jerard, B. (2019). Botany, origin and genetic resources of coconut. In: "The Coconut Palm (*Cocos nucifera* L.)- Research and Development Perspectives".). pp. 57-111. Springer.

Poliana, D. G., Lourdes, M. C., Maria Helena, M. R., Virginia, M. M. & Suely, P. F. (2010). Quality evaluation of grape juice concetrated by reverse osmosis, *Journal of Food Engineering, 96*(3), 421-426.

Purkayastha, M. D., Kalita, D., Mahnot, N. K., Mahanta, C. L., Mandal, M. & Chaudhuri, M. K. (2012). Effect of l-ascorbic acid addition on the quality attributes of micro-filtered coconut water stored at 4 C. *Innovative Food Science and Emerging Technologies, 16*, 69-79.

Rai, P. (2009). Preparation & quality evaluation of ginger wine. B. Tech.(Food) Disseration. Tribhuvan Univ., Nepal.

Rethinam, P. & Krishnakumar, V. (2022). Health benefits of coconut water. In: "Coconut water: a promising natural health drink-distribution, processing and nutritional benefits".). pp. 385-455. Springer.

Ronald, J. & Bakker, J. (2004). "Wine Flavour Chemistry". Blackwell Publishing.

Samosir, Y., Rillo, E., Mashud, N., Lien, V. T. M., Kembu, A., Faure, M., Magdalita, P., Damasco, O., Novarianto, H. & Adkins, S. (2006). Revealing the potential of elite coconut types through tissue culture. Proceedings of the International Coconut Forum held in Cairns, Australia, 22–24 November 2005. ACIAR Proceedings No. 125.

Satheesh, N. & Prasad, N. B. L. (2013). Production of fermented coconut water beverages. *Asian Journal of Food and Agro-Industry, 6* (5), 281-289.

Shahbandeh, M. (2023). Global coconut production 2000-2021. Retrieved fromhttps://www.statista.com/statistics/577497/

worldcoconutproduction/#:~:text=Global%20coconut%20production%202000%2D2021&text=This%20statistic%20depicts%20coconut%20production,about%2063.7%20million%20metric%20tons. (Last update Jan 19, 2023).

Shayanthavi, S., Kapilan, R. & Wickramasinghe , I. (2024). Comprehensive analysis of physicochemical, nutritional, and antioxidant properties of various forms and varieties of tender coconut (*Cocos nucifera* L.) water in Northern Sri Lanka. *Food Chemistry Advances, 4*, 100645.

Soares, L. S. O., Abreu, V. K. G., Lemos, T. D. O., Silva, D. J. S. & Pereira, A. L. F. (2016). Coconut water wine: physicochemical and sensory evaluation. *RECyT, 18*(1), 19-25.

Sousa, E. C., Uchôa-Thomaz, A. M. A., Carioca, J. O. B., Morais, S. M., Lima, A. D., Martins, C. G., D., A. C., Ferreira, P. A. T., Rodrigues, A. L. M., Rodrigues, S. P., Silva, J. N. & Rodrigues, L. L. (2014). Chemical composition and bioactive compounds of grape pomace (*Vitis vinifera* L.), Benitaka variety, grown in the semiarid region of Northeast Brazil. *Food Science and Technology, 34*(1), 135-142.

Stratil, P., Kubáň, V. & Fojtová, J. (2008). Comparison of the phenolic content and total antioxidant activity in wines as determined by spectrophotometric methods. *Czech Journal of Food Science, 26*, 242–253.

Sunil, L., Prakruthi, A., Prasanth Kumar, P. K. & Gopala Krishna, A. G. (2020). Coconut Water Nature's miracle health drink Chemistry, Health Benefits, Packaging, Storage and Technologies : A Review. *Indian Coconut Journal, 63*(7), 15-24.

Tan, T. C., Cheng, L. H., Bhat, R., Rusul, G. & Easa, A. M. (2014). Composition, physicochemical properties and thermal inactivation kinetics of polyphenol oxidase and peroxidase from coconut (*Cocos nucifera*) water obtained from immature, mature and overly-mature coconut. *Food Chemistry, 142*, 121–128. https://doi.org/10.1016/j.foodchem.2013.07.040

Umar, R., Naz, A., Razzaq, K., Raza, N., Faroon, U., Sharif, M., Naz, N., Ahmad, S. & Waheed, U. (2022). Physicochemical comparison of black and green grapes varieties and sensory evaluation. *International Journal of Agriculture Extension,10* (1), 219-231.

Xia, Q., Li, R., Zhao, S., Chen, W., Chen, H., Xin, B., Huang, Y. & Tang, M. (2011). Chemical composition changes of post-harvest coconut inflorescence sap during natural fermentation. *African Journal of Biotechnology, 10*(66), 14999-15005. https://doi.org/10.5897/AJB10.2602.

Yong, J. W., Ge, L., Ng, Y. F. & Tan, S. N. (2009). The chemical composition and biological properties of coconut (*Cocos nucifera* L.) water. *Molecules, 14*(12), 5144-5164. https://doi.org/10.3390/molecules14125144

Yuyuen, P., Boonkerd, N. & Wanapu, C. (2015). Effect of grapes berry quality on wine quality. *Suranaree Journal of Science and Techology, 22*(4), 349-356.