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CARROT-GINGER WINE: PRODUCTION AND QUALITY ANALYSIS

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ABSTRACT

Wine, apart from being widely consumed as an alcoholic beverage, also possesses some beneficial impacts on an individual's well-being. Carrot (Daucus carota) is recognised for its high mineral content, plenty of antioxidants, dietary fibre, and vitamins, particularly Vitamin A. The rhizomes of ginger (Zingiber officinale) possess a distinct and strong taste, as well as various beneficial and medicinal qualities. These include antibacterial, pain-relieving, fever-reducing, anti-inflammatory, anti-cancer, antioxidant, and digestive health-supporting properties. These properties are attributed to the presence of numerous bioactive compounds such as terpenes, oleoresins, gingerols, and shogaols. An endeavour was undertaken to create a wine by blending the juices of carrot and ginger. They underwent a series of steps including cleaning, peeling, and crushing, fermentation (by being mixed with Saccharomyces cerevisiae). After the completion of the fermentation process physiochemical analysis of wine was carried out for studying residual sugar, apparent fermentation degree, fermentative capacity, fermentative velocity, and several supplementary techniques. The wine produced through vegetable fermentation exhibited a color spectrum ranging from cherry red to ruby red, alcohol content ranging from 10 to 12 percent. No noticeable variations in the biological constituents of the wine were detected. Based on the results of a sensory evaluation of the vegetable-based wine, it was determined that it had a pleasant taste and was deemed suitable for consumption in terms of health considerations.

Keywords: Alcoholic beverage, Carrot, Ginger, Fermentation, Saccharomyces cerevisiae, Vegetable wine

1. INTRODUCTION

Wine is a widely consumed alcoholic beverage made via fermentation and known for its nutritional value (Saranraj et al., 2017; Berry, 1995). Alcoholic content in wine lies between 5.5 and 15.5 percent alcohol by volume (Baschali et al., 2017). Wine can be made from many fruits, vegetables, and herbs, in addition to grapes, retaining the characteristics of the original ingredient (Liang et al., 2021). The yeast metabolises the sugar in grapes to produce ethanol, carbon dioxide, and heat (Joshi et al., 2017). Various varieties of wines are created by altering the grape variety and yeast strains. Although grape-based wines are commonly preferred, non-grape-based wines can exhibit outstanding flavours (Mirabito et al., 2017; Sheikh and Islam,2018; Meybodi et al., 2021). Non-grape wines, also referred to as "country wines," are typically produced using a diverse range of fruits (such as apples, strawberries, pineapples, and elderberries), flowers (such as lavender, hibiscus, dandelion, and broom flower), herbs (such as parsley, comfrey, parsnip, and rosemary), vegetables (such as beets, peapods, potatoes, and pumpkins), grains (such as rice, wheat, barley, and corn), and even wines with unconventional ingredients (such as garlic, ginger, green tea, oak leaf). (Matei, 2017; Ludvig et al., 2016)

Wines made from vegetables are rare and not easily obtainable globally (Jagtap and Bapat, 2015). Most commercially available vegetable wines are made by passionate and innovative home winemakers. Ifie et al. (2012) produced dark crimson Roselle calyx from Hibiscus sabdariffa. The fully developed roselle wine exhibited a colour, aroma, taste, and level of acceptability that were comparable to those of commercial wines. Kempraj and Dasgupta (2011) conducted a study comparing the fermentation of beetroot and carrot wine, using Saccharomyces cerevisiae INVSc1 yeast, with grape wine. The sensory research indicated that vegetable wine displayed higher flavour and visual attributes in comparison to grape wine. There are only a few companies globally that specialise in manufacturing vegetable wines. However, none of them are prepared to reveal their formulae and techniques for creating these distinct and delightful beverages, despite producing them in large amounts. Irrespective of the type of ingredients used, such as grapes, other fruits, vegetables, or herbs, the basic methods and tools used in making wine are mostly the same.

The carrot, scientifically referred to as Daucus carota, is a root vegetable often promoted as an excellent option for maintaining good health (Ahmad et al., 2019). The dish exhibits a crunchy consistency, delightful taste, and substantial nutritional content (Raees-ul, and Prasad, 2015). Carrots are a highly beneficial source of beta carotene, fiber, vitamin K1, potassium, and antioxidants. Moreover, they provide a multitude of health benefits (Surbhi et al., 2018). They are a type of food that encourages weight loss and has been linked to lower cholesterol levels and improved eye health (Ahmad et al., 2019). Furthermore, the carotene antioxidants present in their carotene have been linked to improved immune function and reduced vulnerability to certain diseases, such as heart disease, degenerative disorders, and specific types of cancer (Bahram et al., 2018; Asdaq et al., 2020; Mughal et al., 2020).

Ginger (Zingiber officinale) not only enhances the flavour of food, but it is also rich in vital nutrients (Özcan, 2022). The root has been employed for gastronomic and therapeutic purposes for thousands of years (Shahrajabian et al., 2019). The therapeutic qualities of ginger are well-documented in ancient writings from Rome, Greece, China, and Arab countries (Agrahari et al., 2015). The main active constituents included in ginger essential oil are α-curcumene, α-zingiberene, geranial, β-sesquiphellandrene, β-bisabolene, and neral (Dhanik et al., 2017). Ginger essential oil is renowned for its extensive bioactivity and its ability to promote health (Shaukat et al., 2023). It became very famous in Asian medicine due to its effectiveness in treating gastrointestinal issues, such as nausea and diarrhoea. Presently, ginger is still considered a natural cure for reducing gastrointestinal discomfort, and scientific research offers substantiation for its beneficial impact on health (Mao et al., 2019).

Considering the aforementioned health aspects of both vegetables, wine was prepared from their combination. This study aimed to develop a systematic protocol for producing vegetable wine using various combinations of carrot-ginger blends. The present investigation analyzed the nutritional attributes of carrots and ginger. These substrates can be converted into long-lasting goods, such as wine, that can be stored for extended periods. This allows buyers to benefit from these things when they are not readily available. Therefore, incorporating value-added characteristics can enhance the market potential and elevate the economic value.

2. METHODOLOGY

The present project work was carried out in the Department of Biotechnology, Government College, Hisar.

2.1 Substrate

The fresh and ripened carrot and ginger were acquired from the neighborhood market of Hisar (Haryana) and were utilized for the readiness of wine.

2.2 Inoculum preparation

Pure Saccharomyces cerevisiae strain cultures were obtained from the Biotechnology lab of Government College, Hisar. The cultures were maintained on YEPD medium (yeast culture). For preparation of yeast (S. cerevisiae) inoculum, sterilized grape juice was used. A loopful of 24 hrs. old yeast grown on agar slant was transferred aseptically to 10 ml of grape juice and allowed to grow for 24 hrs at 30^{o} C. The whole contents of the tube were transferred to 100 ml of sterilized grape juice and incubated at 30^{o} C/24 hrs under mild shaking conditions and were used as inoculum for wine production.

2.3 Extraction of juice from carrot, and Ginger

Carrot and ginger that had reached full ripeness were thoroughly washed with running water, and the mash (pulp) was separated physically. The liquid was then manually squeezed through muslin fabric after the mash had been finely crushed in a blender.

2.4 Preparation of wine from carrot, and ginger

Juice was blended in different ratios for winemaking. To 1 kg of carrot juice, 5% of ginger juice was added. The final blend of juices was sterilized and various parameters like pH, specific gravity, TSS were measured. The must was divided in three sets SET I, SET II and SET III. Brix of the sets were adjusted to 22, 24, and 26^{o} brix. Brix adjustment and flavor enhancement was done by adding orange juice and sugar. Then, these sets were pitched with S. cerevisiae yeast inoculum for anaerobic fermentation at 20° brix. Anaerobic fermentation continued for a period of seven days and the progress of fermentation was monitored by measuring the drop of TSS. After completion of wine formation, its filtration, clarification, and racking were done. For chemical analysis, samples were taken at regular intervals. Various parameters such as alcohol content, pH, specific gravity, TSS, titrable acidity, etc., were carried out

2.5 Analysis of wine

The wine was analyzed during the storage period and biochemical changes were recorded at different time intervals. In a measuring cylinder with 50 ml of sample, the specific gravity of wine samples was calculated using a hydrometer (with the proper temperature correlation factor) (20^o C). Calculations for residual sugar (RS), apparent fermentation degree (AFD), fermentative capacity (FC), fermentative velocity (VC), and attenuation were then made using the specific gravity values that had been acquired (American Society for Brewing Chemists, May and Shape (2004). Fresh wine prepared from different blends was analyzed by using the following physicochemical characteristics.

2.5.1 Detection of Ethanol A 1L volumetric flask containing 34g of potassium dichromate was dissolved in 500 ml of pure water. The volumetric flask was placed in an ice container and 325 ml of concentrated H_2SO_4 was added drop-by-drop to minimize heat generation. Thoroughly mixed, cooled, and diluted the solution to 1L with purified water. Pipetted 1 ml sample into a volumetric flask, then added 10 ml dichromate reagent. The mixture in the flask was incubated at 60˚C for 20 minutes in a water bath and chilled. Volume was made 50ml using distilled water. The linearity curve was plotted using ethanol concentrations from 1 to 10% (v/v) and a blank solution made with distilled water at 600 nm. (Tupe et al., 2018; Caputi et al., 1968)

2.5.2 Detection of pH The pH meter was activated. The electrode was rinsed with distilled water. Subsequently, the instrument was calibrated using a buffer solution. The sample was positioned and we patiently waited for a stable measurement. Reading was observed.

2.5.3 Detection of Vitamin C Iodine titration was used to evaluate the vitamin C level. Measured 2 g KI and 1.3 grams I_2 precisely. Completely dissolved them in a tiny amount of water by shaking. Filled a 1L volumetric flask with the iodine solution, rinsed any remains with distilled water, and filled to the mark. 0.25 grams of soluble starch was added to a 100 mL conical flask or beaker with 50 mL of distilled water to make a 0.5% starch indicator solution. Heated the solution at 79°C for 5 minutes with stirring. Transfer 20 ml of wine sample solution to a 250 ml conical flask with 150 mL distilled water and 1 mL starch indicator solution. Samples were titrated with 0.005 mol L−1 iodine solution. The starch-iodine combination provides the first dark blue-black trace at the titration endpoint. Titration was performed with additional sample solution aliquots until values agreed within 0.1 mL. (Bailey, 1974; Brody, 1994; Pauling, 1976; Kalluer, 1986)

2.5.4 Detection of Reducing Sugar Reducing sugars were calculated using the technique described by Miller. The color tests were made with 3ml. aliquots of dinitrosalicylic acid reagent (DNS) added to 3-ml. aliquots of glucose solution in the test tubes. The mixtures were heated for 5 minutes in a boiling water bath and then cooled under running tap water adjusted to ambient temperature. Cooling to ambient temperature was made necessary by the effect of temperature on the absorbance of the colored reaction product. The color intensities were measured using spectrophotometer at 575 mμ with a slit n width of 0.06 mm. (Miller, 1959)

2.5.5 Detection of titrable acidity The hot plate was prepared to its maximum temperature. A volume of 10.0mL of wine was transferred using a pipette into a glass beaker with a capacity of 100mL. A small number of boiling granules were introduced. The substance was thereafter placed on a hot plate and heated until it reached the boiling point, after which it was swiftly removed. The wine sample was chilled prior to titration. Wine was mixed with recently heated, cooled, purified water. The solution was subsequently titrated with a 0.1M NaOH solution until it reached a pH of 8.2, or until the first long-lasting pale pink hue appeared when using phenolphthalein as an indicator (Iland, 2000; Amerine et al, 1980). The titrable acidity was calculated using the provided formula.

Titrable Acidity (g/l) = [(molarity of NaOH) × {mLs NaOH (sample titration) – mLs NaOH (blank

titration)}] × 75/ mLs of sample.

2.5.6 Detection of Antioxidant activity Stock solutions of the wine fractions were produced with a concentration of 1 mg/mL. Measured amounts of the fractions (determined in initial tests) were transferred to test tubes containing 5 mL of DPPH (1,1-diphenyl-2-picrylhydrazyl radical) solution at a concentration of 23.6 mg/mL in ethanol. This resulted in final concentrations of the fractions ranging from 2 to 96 mg/mL. The samples were subjected to 30 minutes of ultrasonic treatment, after which their absorbance was measured using a spectrophotometer at a wavelength of 517 nm. The percentage radical-scavenging activity (%SA) was determined by the following formula:

$$\%SA = 100 \times (A_{control} - A_{sample}) / A_{control},$$

where Acontrol represents the absorbance of a solution containing only DPPH and ethanol, and Asample represents the absorbance of the DPPH solution in the presence of the wine fractions.

2.5.7 Measurement of °Brix The refractometer is retrieved and calibrated using distilled water. Subsequently, we cleaned it, extracted a sample of the juice, and meticulously recorded the obtained measurement.

2.5.8. Sensory/ Organoleptic Analysis Consumer preferences are often assessed using the 9-point hedonic scale in sensory analysis, especially in wine analysis. This scale lets wine drinkers rate their preferences from "dislike extremely" to "like extremely." To guarantee uniformity, wine samples are served at the same temperature and in the same glassware before analysis. A diverse set of volunteers is then chosen to offer diverse viewpoints. Each participant evaluates a wine sample's fragrance, flavour, mouthfeel, and overall acceptability using the 9-point hedonic scale.

Average scores are calculated by collecting and analysing participant ratings for each attribute. Data research shows consumers' favourite and least like traits. This analysis can guide product development, marketing, and quality control. The 9-point hedonic scale makes consumer preferences easy to assess, helping winemakers improve their goods and customer happiness.

2.6 Statistical Analysis

All the results of the analyses were subjected to Analysis of Variance (ANOVA) to obtain the significance difference between the mean values using Last Significance Difference, LSD ($p < 0.05$) following one-way ANOVA.

RESULT AND DISCUSSION

The current study aimed to examine the process and analysis of vegetable wine production. Typically, to compensate for the low sugar content in most juices and pulp, sucrose is added to increase the sugar content of the juice. Suresh and colleagues adjusted grape must to 22^o Brix using cane sugar. In contrast, when fermenting carrot juice, Lingappa and Naik observed a significantly lower T.S.S. (18^o Brix). Before fermentation, the ginger juice was adjusted to 23^o Brix TSS with sucrose, glucose, and fructose. In the current study, the first three wine blends share the same carrot and ginger composition but have different brix levels. Brix for blend 1 (named CG1) is 22, and it has been increased to 24 and 26 for blends CG 2 and CG 3, respectively. Pure carrot and ginger juice were also used for fermentation at 22 ^{o} Brix (Table 1). Yeast culture was added to the prepared mashes at a ratio of 1g/liter. Prescott and Dunn discovered that the ideal inoculum level for producing wine ranges between 4-6%. To reduce the possibility of fermentation media contamination, Sterehaina and colleagues proposed that an inoculum concentration of 10.0% (v/v) is sufficient for industrial fermentation.

pH is a quantitative measure of the acidic or alkaline nature of a water-containing solution, commonly used in winemaking to determine the acidity of juice or wine (De Souza et al., 2020). While total acidity quantifies the overall concentration of acids in a solution, pH measures the relative strength of acids, recognizing that not all acids are the same strength (Sun, and Berg, 2003). The pH of juice and wine is usually between 3 and 4 (Botezatu et al., 2021). A wine with a low pH will have a sour taste due to its high acid content. On the other hand, a wine with a high pH will have a dull flavor and a lack of freshness (Terblanche, 2019). The pH level in winemaking is critical because it influences microbial stability and the risk of deterioration (Seo et., 2020). Thus, the pH and acidity of the mashes produced were engineered to prevent the growth of undesirable microflora in the fermentation media (Lee et al., 2022). Lingappa and Naik reported that the total acidity of carrot juice should be adjusted to 0.9% using tartaric acid before fermentation. Balogun et al. (2017) found that pH ranged from 3.80 to 3.20. Sales-e-Dias et al. (2018) reported that ginger wine had a pH of 3.45. Nandgopal and Nair's (2013) studies revealed that batch 1 ginger had a pH range of 3.77 -3.59. In the current study, the pH of the carrot-ginger wine ranges between 4.3 and 4.4, indicating a tart flavor.

Lingappa and Naik reduced the total titrable acidity of carrot juice to 0.9% by adding tartaric acid. Vivek and Debjani extracted the vegetable material and combined the must. To reach a pH of 4.5, 250g of cane sugar and citric acid were added to the juice. Ifie and a coworker adjusted the pH of vegetable wine to 3.7 using Hibiscus sabdariffa as a substrate. According to Nandgopal and Nair (2013), the titrable acidity of ginger wine ranged between 2 and 3.5 mg/ml. Patharkar and his coworkers fermented ginger. These mashes were then incubated for 5 days at a constant temperature (25°C). Current research indicates that titrable acidity falls within the range of 3.8-4.1, which is ideal for winemaking.

Kempraj and Dasgupta's study found that the level of reducing sugars in wine is indicative of the quality of these food products, and monitoring the levels of reducing sugars during food production improved market quality. The quantity and rate of sugar utilization are measured by fermentative capacity and apparent fermentation degree, which are both correlated parameters. Fermentation velocity is the rate or percentage of sugar conversion to alcohol (Jangra et al., 2018). Carrot ginger wine in this study had a reducing sugar content of 0.66, indicating a good amount of fermentation.

In addition to its direct effect on yeast activity and growth, temperature has a variety of other effects. High temperatures cause the loss of alcohol and aromatic constituents, as well as the formation of more alcohol and other byproducts (Shenbagamuthuraman et al., 2022). The optimal temperature for alcoholic fermentation ranges between 20 and 28°C. Lingappa and Naik found that carrot wine fermented with immobilized yeast cells at 27°C had a higher ethanol content. Vivek and Debjani fermented vegetable wine (carrot and beetroot) at 32 °C. Balogun et al. (2017) found that the temperature range for carrot pineapple blend was 28°C to 27°C. The black carrot juice was fermented at 25° C by Kocher and colleagues. Ginger wine was kept for fermentation for 21 days at 25°C during study conducted by Sales-e-Dias et al., 2018. Fermentation time varies depending on the vegetable and other fermentation conditions (Zia, and Alibas, 2021). In the current study, the fermentation took about 7 days to complete.

The enological properties of wine developed in the present study are listed in Table 3. For ginger wine specific gravity ranged from 1.116 -1.162 during study conducted by Nandgopal and Nair. After fermentation, there was no pattern in the final specific gravities of the wines. Residual sugar was minimal in all wine blends. Several methods were employed to investigate the physiochemical properties of wine (Table 4). Balogun et al. (2017) found similar results when blending carrot and pineapple wine. Vitamin C levels ranged from 5 to 6.4 g/l in all of the wines. Because of the concentration shift caused by heat lability, vitamin C is an important quality indicator that contributes to the food's antioxidant capabilities (Zia, and Alibas, 2021). Vitamin C levels in the current study ranged between 5.4 and 5.7 mg/100ml, indicating good antioxidant activity. Antioxidant activity in wines was measured as a percentage of DPPH inhibition. Carrot ginger blends CG1, CG2, and CG3 were found to have higher antioxidant activity. According to research, carrots and gingers are vegetables that are anti-inflammatory and antioxidant-rich (Jideani et al., 2021; Sharma et al., 2022; Cuevas-Cianca et al., 2023).

°Brix is a quantitative measurement of the total amount of dissolved soluble solids in 100mL of juice, including pigments, acids, glycerol, and sugar (Bezus et al., 2022). As a result, °Brix can be used to estimate sugar concentrations. Sales-e-Dias et al. (2018) discovered that ginger wine had a Brix of 22.8 degrees. In the current study, °Brix was found to be between 22 and 26 in the first few days. Its value increased as the number of days of fermentation increased, indicating that sugar was converted more efficiently during this period. After 7 days, the final brix value reached zero, indicating that no more sugar was converted in the wine.

Wine evaluation is sensory (Chen and Darriet, 2021). Wine appraisal began with production but was codified in the fourteenth century. Professional wine tasters create words to describe wine flavors, aromas, and characteristics (Malfeito-Ferreira et al., 2021). These findings determine a wine's complexity, character, pleasantness, and flaws. The complexity, character, promise, and defects of our vegetable wines were all evaluated using the same criteria. Semi-trend panelists from Govt. College, Hisar, including students, instructors, and staff, contribute to sensory evaluation (Table 5). Sales-e-Dias et al. (2018) prepared a wine with a sensory evaluation score of 16.8 out of 20, indicating that it has outstanding characteristics and no noticeable flaws.
In the current study, carrot-ginger wine appeared appealing to tasters. It was cherry red to ruby red and transparent. No insoluble particles were visible. The wine's fragrance was subtle but pleasantly sweet. The wine had a robust and invigorating bouquet, followed by the distinct scent of ginger, and finished with a subtle hint of carrot, indicating the presence of a perfectly balanced and mildly sweet wine on the table. The wine had a pleasant sweetness that was complemented by a subtle presence of alcohol. The carrot-ginger wine gave the impression of a viscous, saccharine, astringent fluid. When tasting, almost all wines follow the same pattern (based on non-sensory data). CG3 received the most positive feedback out of the three sets.
Wines made from substrates such as carrot and ginger are thought to be healthy due to the polynutrients found in both carrot and ginger (Lucarini et al., 2021). This wine also contains antioxidants and photochemicals, which help to keep blood sugar levels stable. This wine, which contains antioxidants such as vitamin C, will be extremely beneficial to skin health. So, all of these health benefits were considered when planning this study. This study aims to summarize the entire process of making vegetable wine using substrates such as carrot and ginger. It will help food manufacturers and processors create value-added wine that preserves the nutritional properties of various vegetables.

CONCLUSION

As is well known, wintertime excess carrots and ginger production is squandered due to poor market prices and storage issues. According to the current study, fermentation can be used to transform carrot and ginger into value-added products. Blending can enhance its therapeutic qualities. Because they are less alcoholic than wines sold in stores, these wines are safe to drink regularly and do not pose a health risk. It really offers a host of health advantages. This study demonstrates that a carrot-ginger blend can be used to make drinkable wine. A small-scale wine industry will benefit from the process monitoring and final analysis results, or it can use them as a guide to start one.

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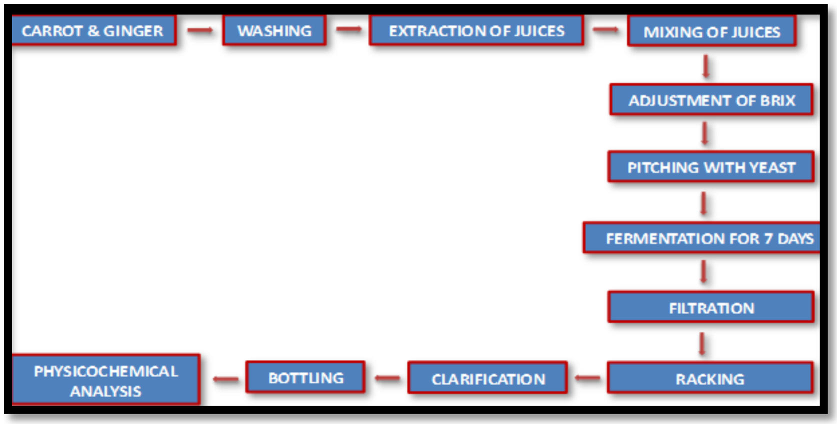

Figure 1: Flow Chart Depicting Carrot Ginger Wine Preparation

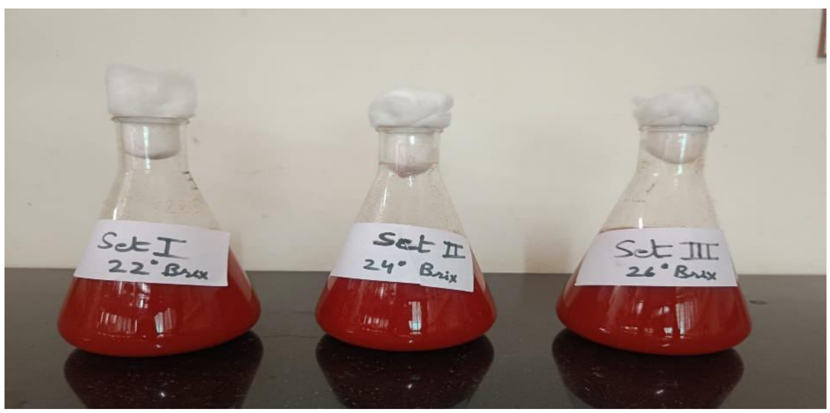

Figure 2: Carrot Ginger Blends Before Fermentation

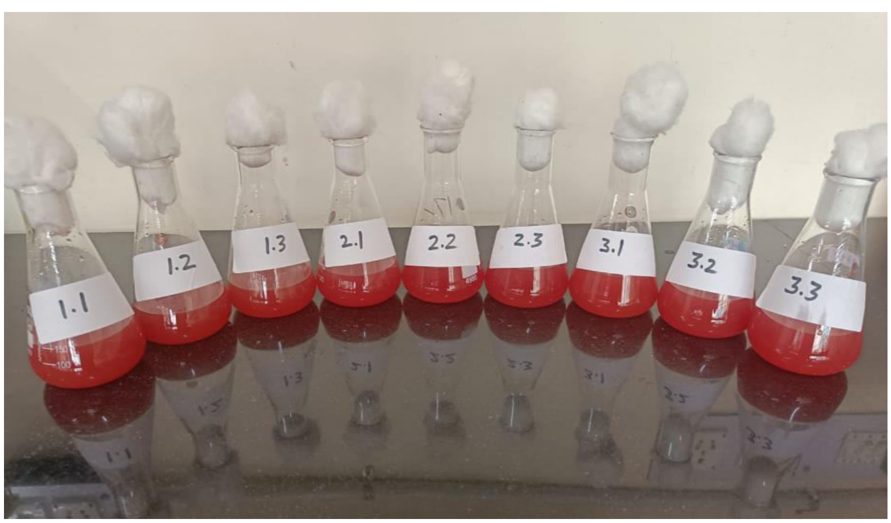

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Figure 3: Carrot Ginger Blends after Fermentation on 7th day

Figure 4: Fermentation at 20°C

Table 1: 9-point hedonic scale

Range	Point	Range	Point
Extremely liked	9	Neither liked or disliked	5
Very Much Liked	8	Slightly disliked	4
Moderately Liked	7	Moderately disliked	3
Slightly Liked	6	Very Much disliked	2
		Extremely disliked	1

Table 2: Physiochemical analysis of different wine samples at a fermentation temperature of 20°C

	Samples		
Physiochemical Parameters	**SET I**	**SET II**	**SET III**
Initial TSS (Brix)	22	24	26
Final TSS (Brix)	0	0	0
Titrable Acidity (g/l)	3.8	3.9	4.1
Alcohol Content (%)	12.07	13.26	14.4
pH	4.41	4.36	4.38

Table 3: Oenological properties of vegetable wine

	Samples		
Properties	**SET I**	**SET II**	**SET III**
Specific Gravity (Initial)	1.092	1.099	1.109
Specific Gravity (Final)	1.000	0.998	0.999

Reducing Sugar (g/100ml)	0.66	0.65	0.68
Apparent attenuation (%)	100	100	100
Apparent Fermentation Degree (%)	8.320	8.401	8.323
Fermentative Capacity (%)	0.090	0.090	0.090
Fermentative Velocity	133.05	133.05	133.05

Table 4: Examination of Antioxidant and Vitamin C content of vegetable wine

	Samples		
Properties	**SET I**	**SET II**	**SET III**
Antioxidant Activity (%)	96	96	95
Vitamin C (mg/100ml)	5.4	5.5	5.76

Table 5: Table illustrating Sensory evaluation of Carrot Ginger wine samples

	Preparations		
Attributes	SET I	SET II	SET III
Appearance	9	8	9
Aroma	8	8	8
Taste	8.5	8.8	8.7
Flavor	9	9	9
Overall Acceptance	8.5	8.5	8.7

Table 6: Table illustrating Non- Sensory evaluation of Carrot Ginger wine samples

	Preparations		
Attributes	SET I	SET II	SET III
Color	Red and transparent	Red and transparent	Red and transparent
Alcohol Content	Natural	Natural	Natural
Relative sweetness	Sweet and astringent	Sweet and astringent	Sweet and astringent
pH	Acidic	Acidic	Acidic
Attributes	Red and transparent	Red and transparent	Red and transparent