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RESEARCH ARTICLE

Paneer whey-apricot drink: Effect of pectinase treatment, dilution ratio and yeast co-culture

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Abstract: This study aimed to optimize the concentration of pectinase enzyme to enhance juice extraction from apricot pulp. It also determined the optimal level of paneer whey as a water substitute in must preparation and standardized the percentage of yeast co-culture to produce high-quality paneer whey-apricot wine. Apricots from Ladakh were pulped to preserve them. The paneer whey was defatted and deproteinized to prevent any adverse effects on the finished product's quality. Due to the high fiber content of apricots, pectinase enzyme was used to break down the pectin in the pulp and release more juice and soluble components. Pectinase was tested at different concentrations (0.2%, 0.5%, and 1%), with 0.5% proving to be optimal because it significantly increased juice yield. To prepare must, this juice was diluted with treated whey in different ratios (1:1 to 3:1). Various chemical parameters were analyzed, including ethanol, methanol, antioxidants, sugar profiles, and sensory evaluation of the different dilutions to assess the acceptability of the final product. The 2:1 dilution received better acceptance compared to the 1:1 and 3:1 dilutions. The 1:1 dilution wine had a thick, intense fruity flavor with high acidity, while the 3:1 dilution resulted in a very light flavor and color, making it less acceptable. Considering the higher ethanol production and sensory ratings, the 2:1 dilution ratio was determined to be the optimal choice for producing good-quality *paneer* whey-apricot wine. The study also analyzed the effect of varying yeast co-culture concentrations on the final wine. Based on the ethanol content in the final wine, 7.5% yeast co-culture was optimized. Finally, the optimized conditions of pectinase, dilution, and yeast co-culture percentages were recommended to prepare *paneer* whey-apricot wine.

Keywords: Whey, Apricot, Wine, Pectinase, *Saccharomyces cerevisiae*, *Kluyveromyces marxianus*

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Introduction

The substantial volume of whey discarded during cheese production at global level and other dairy products at regional level in dairy industries pose a significant environmental concern. India is the largest milk producer of the world with an estimated milk production of 239.30 million tonnes in the year 2023-24 (BAHS, 2024). In general, about 9 L of whey is obtained from 1 kg of cheese produced (Valdez Castillo et al. 2021). The whey is obtained during the preparation of coagulated milk products such as *paneer*, chhana, chakka, etc (Balakrishnan et al. 2024). Whey contains around 55% of milk contents, resulting in a high organic matter concentration, including lactose (70–72% of total solids), whey proteins, vitamins, and salts (Arshad et al. 2023; Panesar and Kennedy, 2012). In India, paneer output is predicted to be 150,000 tons per year, or 1% of total milk production in India. (Balakrishnan et al. 2024) which shows that a huge quantity is produced in the country every year. In India, *Paneer* whey is underutilized in the dairy industry due to a lack of advanced infrastructure and small-quantity production in many small dairies. Many researchers fermented whey and produced products such as whey wine, whey beer, etc. Yamahata et al. (2020) used raw and demineralized whey for alcoholic beverage products and concluded that demineralized whey produced better drinks with higher ethanol content and lacked any milky sensation.

Apricots, highly nutritious stone fruits, are rich in sugars, polyphenols, beta-carotene, and flavonoids, along with soluble fiber. The pectinase enzyme is employed to release these substances into the juice, which acts on the pectin content of apricots, breaking it down and enhancing the juice's flavor. Bashir et al. (2021) reported that increasing the pectinase enzyme from 0.2% to 1%, significantly improved juice yield, clarity, and lightness (L^* value), reducing turbidity and pectin content in the apricot juice. In India, apricots from Ladakh are recognized for

their high quality. Their total output was 15,789 tonnes in 2019, making them the country's largest producer (Stobdan et al. 2021). Apricots, being highly perishable fruits, necessitate prompt processing into value-added products with an extended shelf life. However, the absence of adequate processing facilities in the Ladakh region has led to an estimated 40-50% of apricots being wasted (Stobdan et al. 2021). To reduce this wastage, wine was made from Ladakh apricots in which whey was used as a diluting liquid instead of water.

In India, domestic wines dominate the market due to their lower prices, greater availability, and a high import tariff of 150 percent on imported wines. This, coupled with wine consumption exceeding 30 million litres annually, indicates a substantial market for wine in the country. (MOFPI report, 2023). Yeasts are essential in the wine-making process. They transform the sugar to alcohol. Gómez et al. (2024) noted that *Kluyveromyces marxianus*, starting from an initial concentration of 2.5 × 10w CFU/mL, can be effectively cultivated for high alcohol production using various whey-based matrices. Only 2% of known yeast species are capable of fermenting lactose (Fonseca et al. 2008). *Kluyveromyces marxianus* has a high lactose absorbing capacity and is thermotolerant (Lane & Morrissey, 2010). It is used to produce ethanol from whey or whey-derived media for use as a biofuel (Sansonetti et al. 2009). Yamahata et al. (2020) created an alcoholic beverage from whey, fermented by *K. marxianus* NBRC 1735. *S. cerevisiae* is the most commonly employed yeast for wine production, typically taking over the fermentation process until the sugars are depleted. Fermentation can result in a population of roughly 3 × 10w CFU/mL (Mangani et al. 2020). Comelli et al. (2016) reported that commercial *Saccharomyces cerevisiae* showed effective ethanol production when fermenting fruit juices containing glucose, fructose, and sucrose.

In this study, we attempted wine making by combining apricot pulp and paneer whey, which contains both fruit sugars and lactose. To effectively utilize both types of sugar, we prepared a co-culture of *Kluyveromyces marxianus* and *Saccharomyces cerevisiae*. Chaudhary & Khedkar (2016) also patented a procedure of whey winemaking by inoculated yeasts at the rate of 2-10% (*Kluyveromyces fragilis* NCIM-3465 and *Saccharomyces cerevisiae* NCIM-3300) and claimed 10-10.2% alcohol in the final product.

Acid whey has a relatively high lactose-to-glucose ratio and an acidic taste, which makes it unpleasant to the palate. Therefore, flavor improvement is necessary (Fagnani et al. 2018; Yamahata et al. 2020). In this context, Gómez et al. (2024) attempted to prepare alcoholic beverages by mixing separately fermented orange juice or strawberry pulp by *S. cerevisiae* and whey by *K. marxianus* in a 1:1 ratio and reported that *K. marxianus* LFIQK1 strain revealed desirable lactose-fermenting activity. Several researchers reported that blending whey and fruit juices or pulps could be an attractive way of developing whey-based beverages and valorising whey (Fagnani et al. 2018; Janiaski et al. 2016). Studies on alcoholic beverages produced by fermenting the "must," which is a composite of whey obtained during the production of paneer, chhana, shrikhand, and other dairy products, along with fruit juices or pulp, are scarce. This study aimed to optimize the pectinase concentration to enhance yield, the ratio of whey to apricot pulp, and the yeast inoculum level in paneer whey-apricot wine.

Materials and Methods

Materials

Fresh apricots (*Prunus armeniaca*) were sourced from the Alchi, Leh, and Saspol regions of Ladakh, India. Paneer whey was collected from the Experimental Dairy Plant of the ICAR-National Dairy Research Institute (NDRI), Karnal, Haryana. All chemicals, microbiological media, and enzymes used in the study were obtained from reputable laboratory chemical suppliers. Specifically, M/s CDH chemicals, M/s Hi-media, and M/s SRL, India, provided AR/GR grade chemicals. Granulated sucrose was sourced from the local market of Karnal, Haryana. Yeast cultures of *Saccharomyces cerevisiae* (NCDC-45) and *Kluyveromyces marxianus* (NCDC-39) strains were obtained from the National Collection of Dairy Culture (NCDC), ICAR-NDRI, Karnal, Haryana.

Yeast culture preparation

Freeze-dried yeast cultures were grown on potato dextrose broth (PDB) with at least two sub-cultures. These sub-cultures were used to prepare the 16-hour-old inoculum (8 logs CFU/mL) for further experiments and product preparation. The pH of PDB was adjusted to 3.5-4 and incubated at 28°C for 48 hours. The stock culture of yeasts was maintained at -20°C in PDB containing 20% glycerol. The yeast inoculum was propagated in sterilized, treated (defatted and deproteinized) whey at 28°C for 48 hours. This inoculum was used as the starting point for the paneer whey-apricot pulp must. Both yeast cultures were sub-cultured fortnightly on potato dextrose agar (PDA) media.

Physico-chemical and microbiological analyses

Raw *paneer* whey and treated whey samples were analyzed for various physicochemical parameters including total solids (TS), fat, protein, lactose (Lane-Eyon method) and ash contents, pH, and titratable acidity by adopting standard methods (AOAC, 2023). While the instrumental color values were recorded using by a colorimeter (Hunter colorlab). Apricot pulp was analyzed for TS, total soluble solids (TSS), fat, crude protein, total and reducing sugars (Ranganna, 1986). Also, titratable acidity, ash content, phenolics (Paixão et al. 2007), beta-carotene (Aremu and Nweze, 2017), antioxidant acitivity (DPPH) (Carmona-Jiménez et al. 2014), crude fiber (AOAC, 2023), and instrumental color values. To determine the yeast count of inoculum, dilution of colonies was grown on PDA media plates at 28°C for 3 days, and the results were expressed as CFU/mL. The effect of pectinase treatment on

apricot juice was analyzed by estimating physicochemical properties, including juice yield, TSS, TS, acidity, pH, total and reducing sugar, phenols, antioxidants, ash, and color values. The effects of different dilution rates and yeasts co-culture percentage were analyzed based on the estimation of the rate of fermentation (RF) which was calculated by dividing the decrease in TSS (Initial TSS-Final TSS) by the total days of fermentation, TSS was recorded using an ERMA handheld refractometer (0-32°B) at 20°C and expressed in °Brix (Ranganna, 1986). The ethanol (FSSAI 13.003:2021) and methanol (FSSAI 13.028:2021) contents in the wine were determined by the Gas Chromatography method (FSSR, 2005). The light transmittance (Ma et al. 2020), titratable acidity (Dubois et al. 1956) expressed in % maleic acid, volatile acidity (Amerine, 1980), total sugar (Dubois et al. 1956), reducing sugars (FSSAI 13.035:2021), sugar profiling which includes glucose, fructose, maltose, lactose, and sucrose using the HPLC method (Kim et al. 2018), phenols (Paixão et al. 2007), antioxidant activity in terms of DPPH and ABTS (Oszmiański et al. 2011), esters (FSSAI 13.010:2021), ash, and instrumental color values of wine were also recorded. The sensory evaluation of wines was done according to the Davis 20-point scorecard (Langstaff, 2010).

Preliminary treatments of fresh apricots and *paneer* whey

The procured apricots were checked to loosen the peel and simultaneously blanched by using a boiled solution of NaOH (0.2%) for 30 seconds and then dipped in KMS (0.2%). The treated apricots were pulped, vacuum-packed, and stored under refrigerated conditions. *Paneer* whey was defatted by a cream separator and deproteinized at 85°C for 30 min, cooled to room temperature, and kept undisturbed for 3-4 hours. It was filtered using a double-layered muslin cloth to obtain treated whey (Chaudhary & Khedkar, 2016).

***Paneer* whey-apricot winemaking procedure**

Pectinase was added in the must which acts on the pectin content of apricot pulp and increases the apricot juice yield. The treated *paneer* whey was used to dilute the apricot pulp for must preparation. Sucrose was added to increase the TSS to 24°B, pH was adjusted to 4.5 by using a citric acid solution (2%), and sodium benzoate was added @ 300 ppm to chemically sterilize the must. Yeast co-cultures were inoculated in the must preparation and incubated at 28°C for 15-20 days. Yeast co-cultures include *K. marxianus* to utilizes the lactose that constitutes the main sugar in *paneer* whey and *S. cerevisiae* utilizes other sugars in the must, primarily sucrose and glucose, and produces alcohol and carbon dioxide. Fresh wine was siphoned from the fermenter and the obtained wine was filled in a dark-colored glass bottle, crown-corked, and pasteurized at 63°C for 30 minutes.

Optimization of the levels of pectinase, dilution and yeast co-culture

Fifty grams of apricot pulp was taken in a 200 mL beaker, and a specified amount (0.2, 0.5 and 1.0%) of pectinase (300 IU) was added for liquefaction. After thorough mixing, the samples were incubated (45°C for 5 h) followed by inactivation of the enzymes by heating (80 °C for 3 min) and cooling (45 °C) to obtain liquefied pulp. Later, it was filtered and centrifuged (3000 rpm for 10 min) to obtain clear juice. The concentration of pectinase that gave maximum juice yield from the apricot pulp was considered optimum for the extraction of juice. The treated whey was used to dilute the apricot pulp in three different ratios (1:1, 2:1, and 3:1) for must preparation. The produced wines were analyzed to optimize the level of dilution to produce good quality wine, which was based on the ethanol percentage and the sensory scores of the wine. The *paneer* whey-apricot juice mixture was treated with three different inoculum concentrations (5%, 7.5%, and 10%). The production of ethanol and methanol, the rate of fermentation, the total soluble solids (TSS), the total solids (TS), the titratable acidity (TA), the volatile acidity (VA), the pH, the reducing and total sugars, the phenolic content, the ester formation, the DPPH scavenging activity, the ABTS radical cation activity, the ash content, and colorimetric values were assessed. The ethanol content of the finished wine was used to determine the ideal proportion of the yeast co-culture.

Statistical analysis

One-way ANOVA was used to examine the effects of pectinase treatment, dilution ratios, and varying degrees of yeast co-culture percentage on the sample. An independent sample t-test was used to investigate the effect of defatting and deproteinization on the whey composition of the raw paneer whey sample.

Results and Discussion

Physico-chemical properties of apricot pulp

The moisture and total solids content in the procured apricots were 80.78% and 19.22%, as given in Table 1. The major constituent in apricot pulp is total sugars, which comprise 51.56% of total solids and contribute to its high TSS content of 18.33°B. Naryal et al. (2019) found that the TSS content for 162 apricot genotypes varied from 10.7 to 37.6°B, with an average value of 20.7±5.1. The total sugar content in the procured apricot was 9.91%, comparatively less than the results reported by Jawdat Jaafar (2021) which is 11-13% in fresh apricots. Karatas (2022) reported the major sugar in wild apricots was sucrose which is 6.80 to 8.33%. Usmanova et al. (2023) reported 17-21.5% sugars in Uzbekistan apricots. Naryal et al. (2019) mentioned the composition of individual sugars of apricots which includes sucrose (57.8%), glucose (19.4%), fructose (14.3%), and sorbitol (8.4%). The pH and titratable acidity of the apricot pulp were 4.53 and 0.464 %M. A., which gives the final wine an acidic taste and

requires dilutions to make the final wine sensorily acceptable. The ash content of the apricot pulp was 2.09%, which decreases the clarity and sensory acceptability of the final wine, as it gives a salty taste to the wine. The crude fiber content of apricot pulp was 1.54% and the same result was also reported by Ali et al. (2011) and Haciseferoçullari et al. (2007) that apricots contain 1.5-2.4% dietary fiber. It affects juice yield and decreases the clarity of the wine. The beta-carotene is a fat-soluble pigment found in the apricot pulp at 19.52 mg per 100g, which gives the apricot a yellow color estimated in terms of *b** value. The total phenolics compound in 100g apricot pulp was 61.73 mg gallic acid equivalent (GAE), which directly contributes to the antioxidant properties of the fruit and the major phytochemicals include rutin, chlorogenic acid, and catechin (Carbone et al. 2018; Fratianni et al. 2022). Additionally, its DPPH value indicates a 61.71% inhibition, highlighting the potential health benefits of apricots. Gómez-Martínez et al. (2021) reported that the major antioxidant capacity of apricot is due to the peels, which contain 8 to 10 times higher polyphenols than apricot pulp. The apricot pulp had a yellowish-orange color, with lightness (*L**), redness (*a**), and yellowness (*b**) values of 67.76, 19.4, and 58.37, respectively.

Physico-chemical properties of treated and untreated *paneer* whey

The moisture content of treated *paneer* whey (TPW) significantly ($p<0.05$) increased, and the total solids decreased due to the removal of fat and protein from *paneer* whey (PW), as shown in Table 2. The PW was defatted and deproteinized, as fat and protein reduce the clarity and adversely affect the appearance of the wine. Generally, wine is stored for a long time and the presence of fat may lead to rancidity and adversely affect the sensory qualities of aged wine. Importantly, the treatment did not significantly ($p<0.05$) affect the lactose content of the whey, which is advantageous because it serves as a substrate for *K. marxianus* which converts it into ethanol during fermentation. Yamahata et al. (2020) reconstituted the demineralized whey powder (DMW) and raw whey powder (RW) and reported that DMW has significantly ($p<0.05$) higher lactose content compared to RW which resulted in higher ethanol production in the final product compared to DMW. There was a significant increase ($p<0.05$) in titratable acidity in the TPW, likely due to the concentration of acids resulting from a decrease in moisture content. There was a significant decrease ($p<0.05$) in the **TSS** of TPW, likely caused by the high heat treatment during the deproteinization process, which may lead to the precipitation of soluble minerals. This finding is also reflected in the ash content of the TPW, which was significantly lower ($p<0.05$) than that of the PW. This reduction is advantageous for the sensory quality of the wine, as it prevents saltiness in the final wine. Yamahata et al. (2020) also reported that demineralized whey wine was sensorily more acceptable than raw whey wine. The lightness (*L**) value of TPW was significantly increased ($p<0.05$) as the clarity of the whey improved following treatment. Similarly, the greenness (*a**) and redness (*b**) color values also exhibited an increasing trend in TPW compared to PW.

Table 1: Physico-chemical properties of apricot pulp

Parameters	Mean ± SD
Moisture (%)	80.78±0.15
Total solid (%)	19.22±0.15
Total Soluble Solids (°B) at 20°C	18.33±0.06
Total Sugar (%)	9.91±0.18
Reducing Sugar (%)	6.5±0.14
pH	4.53±0.05
Titratable acidity (% maleic acid)	0.424±0.01
Ash (%)	2.09±0.15
Crude Fiber (%)	1.54±0.04
Beta-Carotene (mg/100g)	19.52±0.11
Total phenolics (mg GAE/100g)	61.73±0.93
DPPH (%inhibition)	61.71±0.39
Color values	
*L**	67.76±0.05
*a**	16.40±0.04
*b**	65.37±0.05

Effect of different levels of pectinase on apricot juice yield and its physico-chemical properties

Apricot juice treated with 0.2% and 0.5% pectinase showed a significant increase in juice yield ($p<0.05$), yielding 8.58% and 16.92% more, respectively, compared to the untreated juice (0% enzyme), as presented in Table 3. However, as the enzyme concentration increased from 0.5% to 1%, there was a non-significant ($p>0.05$) increase in juice yield compared to untreated juice. Sikodia et al. (2024) also reported similar findings following enzyme treatment of juice, which significantly ($p<0.05$) increased juice yield, filterability, clarity, polyphenols, reducing sugars, and acidity, while reducing the pH. These values varied with the type of fruit. As the concentration of pectinase increased from 0% to 1%, there was a significant increase ($p < 0.05$) in the TSS and TS content of apricot juice. This increase is due to the breakdown of the pectin structure in the apricot pulp, which allowed for the release of more soluble compounds, including reducing sugars, total sugars, and acids into the juice. The reducing sugar content in the treated juice increased significantly ($p<0.05$) by 7.84% and 6.9% when treated with 0.2% and 0.5% pectinase enzyme, respectively. However, raising the pectinase concentration from 0.5% to 1% did not result in a significant ($p<0.05$) increase in reducing sugars, and a similar trend was noted for total sugars. There was a significant ($p<0.05$) increase in the phenolic content of treated juice with the increase in pectinase concentration, as pectinase breaks the pulp structure and releases more

polyphenols and flavonoids in the wine. The same pattern was shown by DPPH which significantly ($p<0.05$) increased from 62.39 to 65.06 % inhibition with the increase in the pectinase concentration from 0 to 0.5%. However, a further increase in pectinase concentration from 0.5% to 1% did not increase the DPPH value. Choi et al. (2020) noted the same results as pectinase-treated wine showed significantly ($p<0.05$) higher DPPH, flavonoids, and total phenols from the untreated wine sample. There was no significant ($p>0.05$) difference in the ash content between the untreated and treated apricot juices and the same was also reported by Bashir et al. (2021), that pectinase treatment does not significantly ($p>0.05$) affect the ash content of apricot juice. The lightness (L^*) value of the treated juices was significantly ($p<0.05$) increased, and more clear apricot juice was obtained. The significant ($p<0.05$) increase was also shown by greenness (a^*) and yellowness (b^*) values. Kushawah and Firdos (2022) reported that 0.3% pectinase esterase enzyme was ideal for producing high-quality wine from wild apricots. In this study, the results of 0.5% treated apricot juice showed significant ($p<0.05$) increases in juice yield, total and reducing sugars, total phenols, DPPH, and clarity of apricot juice, which are important attributes for producing superior quality wine. Consequently, 0.5% pectinase concentration was the optimized condition to produce high-quality wine.

Table 2: Physico-chemical analysis of *paneer* whey and treated *paneer* whey

Parameters	Raw Whey	Treated Whey
Moisture (%)	93.66 ± 0.04^b	94.07 ± 0.07^a
Total solid (%)	6.44 ± 0.04^a	5.93 ± 0.07^b
Fat (%)	0.35 ± 0.05^a	ND^b
Protein (%)	0.54 ± 0.02^a	ND^b
Lactose (%)	4.82 ± 0.03^a	5.37 ± 0.04^a
Total Soluble Solids (°B) at 20°C	6.27 ± 0.06^a	5.84 ± 0.05^b
pH	5.41 ± 0.01^a	5.38 ± 0.04^a
Titratable acidity (% lactic acid)	0.234 ± 0.004^b	0.241 ± 0.004^a
Ash content (%)	0.669 ± 0.005^a	0.385 ± 0.002^b
Color values		
L^*	90.9 ± 0.34^b	96.47 ± 0.32^a
a^*	-14.68 ± 0.36^b	-24.4 ± 0.09^a
b^*	30.85 ± 0.61^b	32.62 ± 0.28^a

Mean ± SD; %; ND, Not detectable.

Table 3: Effect of different levels of pectinase on the physicochemical properties of apricot juice

Parameter	Pectinase Treatment			
	0%	0.2%	0.5%	1%
Juice yield (%)	54.54 ± 0.72^c	59.22 ± 0.43^b	69.24 ± 0.45^a	69.69 ± 0.17^a
TSS (°B) at 20°C	19.63 ± 0.06^d	19.97 ± 0.05^c	20.27 ± 0.06^b	20.5 ± 0.1^a
Total Solids (%)	21.36 ± 0.02^d	22.15 ± 0.02^c	22.4 ± 0.06^b	22.79 ± 0.08^a
Titratable acidity (% maleic acid)	0.433 ± 0.003^c	0.454 ± 0.002^b	0.460 ± 0.002^a	0.462 ± 0.001^a
pH	4.59 ± 0.01^a	4.53 ± 0.02^b	4.46 ± 0.02^c	4.43 ± 0.03^c
Reducing sugars (%)	7.65 ± 0.09^c	8.25 ± 0.05^b	8.82 ± 0.08^a	8.91 ± 0.05^a
Total sugars (%)	10.19 ± 0.12^c	11.39 ± 0.05^b	12.74 ± 0.12^a	12.91 ± 0.05^a
Total phenols (mg GAE/100g)	63.12 ± 0.4^b	64.03 ± 0.48^b	67.85 ± 0.55^a	68.21 ± 0.74^a
DPPH (%Inhibition)	62.39 ± 0.51^c	63.89 ± 0.21^b	65.06 ± 0.34^a	64.73 ± 0.49^a
Ash (%)	2.13 ± 0.04^a	2.16 ± 0.04^a	2.12 ± 0.02^a	2.16 ± 0.04^a
Color values				
L^*	68.45 ± 0.06^d	68.9 ± 0.06^c	69.12 ± 0.05^b	69.25 ± 0.09^a
a^*	17.26 ± 0.04^b	17.37 ± 0.08^b	17.77 ± 0.05^a	17.66 ± 0.06^a
b^*	67.42 ± 0.06^d	67.73 ± 0.01^c	67.91 ± 0.05^b	68.88 ± 0.04^a

Mean ± SD (n=3); M. A. Maleic Acid; GAE Gallic Acid Equivalent
a,b,c,dMean values with different superscripts within rows differ significantly ($p<0.05$)

Effect of dilution levels of apricot pulp and treated whey on the physico-chemical characteristics of wine

As the dilution rate increased from one part of whey to three parts of whey for the dilution of one part of apricot pulp, there was a significant ($p<0.05$) increase in the fermentation rate from 0.731 to 1.01°B per 24 h, as mentioned in Table 4. The 3:1 diluted must, fermented fastest and completed the fermentation within 20.33 days, followed by 2:1 diluted must in 17.67 days, and 1:1 diluted must in 15.67 days, respectively. Gardner et al. (2020) also noted that dilution of grape juice with water (10.5, 17.2, and 24%) in wine preparation shortened the period of wine production from 126 hours of undiluted juice wine to 121 hours of diluted juice wine. The higher the rate of fermentation, the lower the TSS (9.13°B in 1:1 dilution and 8.27°B in 3:1 dilution) due to the utilization of more sugars by yeasts and produced more ethanol in the final wine, and the same results were also reported by Kushawah and Firdos (2022). Shyam & Joshi (2019) prepared wine from wild apricots and reported the TSS of the wine as 8.2°B, with an acidity of 0.764% and a pH of 3.1. TS also showed the same pattern, which significantly ($p<0.05$) decreased from 9.24% to 8.61%, with an increase in the dilution rate from 1:1 to 3:1. Pu et al. (2023) noted that sugar content decreased during the fermentation of the must while alcohol production increased rapidly in the initial phase. Similarly, Shyam (2019) observed that the fermentation rate was notably high during the early stages but diminished as fermentation progressed toward the end. The ethanol content of the wines significantly increased ($p < 0.05$) from 12.74% to 13.69% as the dilution rate rose from 1:1 to 2:1, while no significant change ($p > 0.05$) was observed at a dilution rate of 3:1. According to regulatory specifications of India (FSSAI), wines (excluding grape wine) should have an alcohol content from 7% to 15.5%. Èakar et al. (2019) also reported that produced wine from apricots has an ethanol content of 9.91%. The gas chromatography analysis of wine samples showed no methanol content, which ensured the safety of product, as shown in Fig. 1. Due to the higher whey content in the 3:1 diluted wine, its light transmittance was significantly greater ($p < 0.05$) than that of the less diluted wine samples.

Table 4 Effect of different dilution levels of apricot pulp with treated whey on the physicochemical characteristics of wine

Parameter	Dilution level		
	1:1	2:1	3:1
Fermentation Rate (°B/24h)	0.731±0.02^{c}	0.870±0.04^{b}	1.01±0.05^{a}
Complete fermentation (days)	20.33±0.58^{a}	17.67±0.57^{b}	15.67±0.58^{c}
Total Soluble Solids (°B) at 20°C	9.13±0.06^{a}	8.63±0.15^{b}	8.27±0.2^{c}
Ethanol (%)	12.74±0.03^{b}	13.52±0.06^{a}	13.69±0.03^{a}
Methanol (%)	*BLQ	*BLQ	*BLQ
Total Solids (%)	9.24±0.05^{a}	8.93±0.08^{b}	8.61±0.06^{c}
Light transmittance	71.48±0.58^{c}	73.83±0.57^{b}	79.51±0.64^{a}
Titratable acidity (% maleic acid)	0.442±0.002^{b}	0.450±0.002^{a}	0.453±0.005^{a}
Volatile acidity (% acetic acid)	0.020±0.001^{a}	0.020±0.001^{a}	0.020±0.001^{a}
pH	4.54±0.03^{a}	4.47±0.02^{b}	4.44±0.03^{b}
Reducing sugars (%)	3.59±0.03^{a}	3.36±0.02^{b}	3.2±0.06^{c}
Total sugars (%)	3.73±0.06^{a}	3.51±0.03^{b}	3.397±0.04^{c}
Glucose (%)	0.268±0.01^{b}	0.442±0.02^{a}	0.250±0.008^{b}
Fructose (%)	0.676±0.001^{a}	0.203±0.005^{b}	0.310±0.006^{b}
Maltose (%)	BLQ	BLQ	BLQ
Lactose (%)	2.19±0.09^{b}	2.56±0.15^{a}	2.76±0.13^{a}
Sucrose (%)	BLQ	BLQ	BLQ
Total phenols (mg/L)	349.7±5.34^{a}	275.71±6.4^{b}	187.07±4.69^{c}
DPPH (%inhibition)	92.6±0.66^{a}	90.98±0.65^{b}	85.75±0.61^{c}
ABTS (%inhibition)	99.01±0.74^{a}	96.88±0.34^{b}	93.87±0.92^{c}
Total esters (g/L of absolute alcohol)	164.97±6.55a	122.4±1.77^{b}	106.03±2.05^{c}
Ash Content (%)	0.633±0.013^{a}	0.544±0.012^{b}	0.455±0.023^{c}
Color Values			
*L**	70.52±0.09^{c}	74.66±0.07^{b}	77.6±0.13^{a}
*a**	6.68±0.04^{a}	5.2±0.20^{b}	2.83±0.07^{c}
*b**	58.73±1.59^{a}	52.66±0.29^{b}	44.84±0.11^{c}

Mean±SD (n=3); ND, Not Detectable; BLQ, Below Limit of Quantification; *BLQ (<0.05), BLQ (<0.1).

^{a,b,c}Mean values with different superscripts within the rows differ significantly ($p<0.05$)

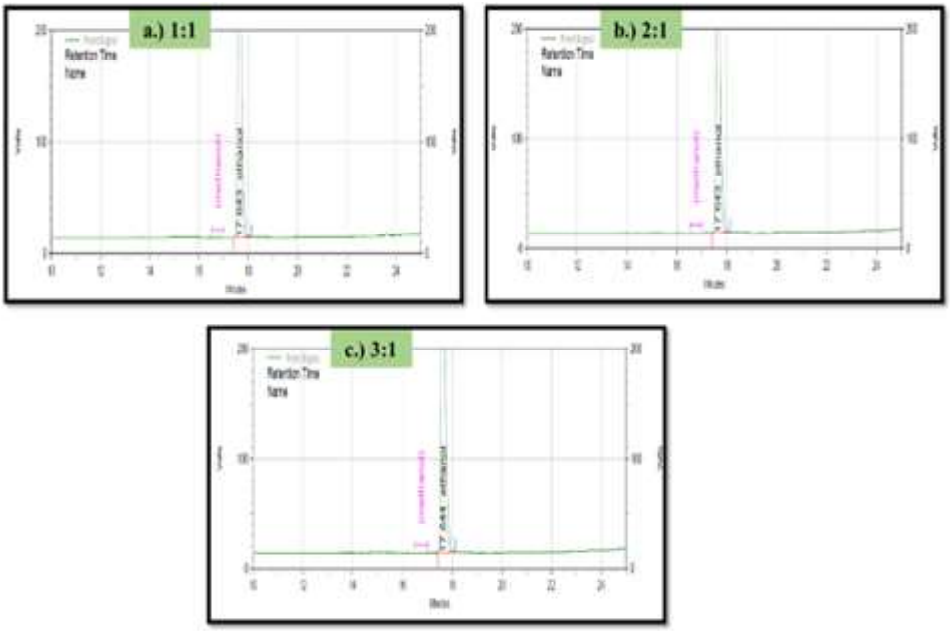

Fig. 1 Gas chromatograms of ethanol and methanol contents of apricot wine as affected by dilution with treated whey a) 1:1, b) 2:1, c) 3:1

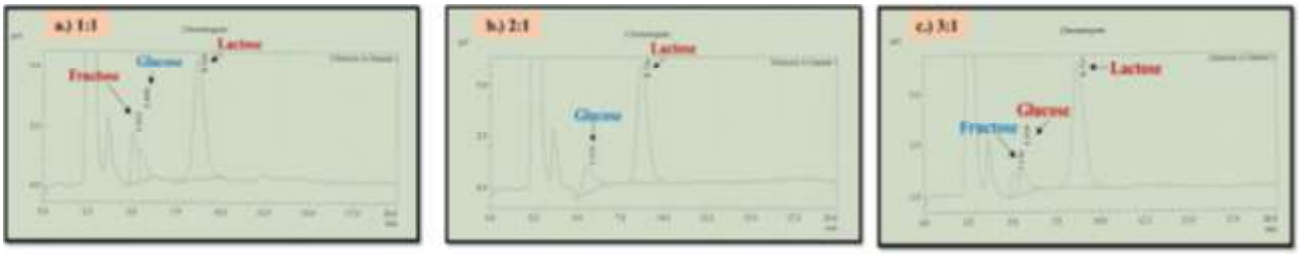

Fig. 2 HPLC chromatograms of the sugar profiling of apricot wine as affected by dilution with treated whey: a) 1:1; b) 2:1, c) 3:1

During the preparation of the must, the pH was maintained at 4.5; however, after fermentation, the pH increased significantly ($p < 0.05$) in the 1:1 diluted wine and decreased with higher dilution rates. The reverse pattern was shown by the titratable acidity which significantly ($p<0.05$) increased as the dilution rate increased from 1:1 to 3:1. Abrol et al. (2019) also reported high acidity in the vermouth due to the high acid content of wild apricots. Cakar et al. (2019) reported that the titratable acidity and pH of apricot wine were 7.71 M.A. (g/L) and 3.72, indicating that the apricot wine had an acidic taste. There was no significant ($p>0.05$) change in the volatile acidity of wine samples, indicating that good hygiene levels were maintained during the wine preparation. Shyam & Joshi (2019) also reported that a low quantity of volatile acidity reflects that there was no contamination of spoilage-causing bacteria in the apricot wine. Gardner et al. (2020) noted that as the dilution of fruit juice used in wine preparation increased, the acetic acid content decreased in the fermentations, reducing from 3.57 mg/L in undiluted juice wine to 0.8 mg/L in diluted juice wine. There was a significant reduction ($p < 0.05$) in total and reducing sugars as the dilution rate increased from 1:1 to 3:1. This reduction may be attributed to the high growth rate of yeast in more diluted wine, which increased sugar utilization during fermentation. The HPLC chromatograms of wine samples for individual sugars analysis revealed that lactose was the major sugar present due to the utilization of whey in wine preparation, followed by fructose and glucose, as shown in Fig. 2. While sucrose was not detected in all wine samples, as it was hydrolyzed into glucose and fructose during fermentation. Choi et al. (2020) also reported that sucrose, glucose, galactose, and fructose were present in the apricot wines, from which fructose was the most abundant reducing sugar (0.599–4.66 g/L). In all wine samples, maltose was not detected. There was a significant ($p < 0.05$) increase in lactose content in the wines, rising from 2.19% to 2.76% as the quantity of whey in the must increased with the dilution rate. *Kluyveromyces* species are less tolerant to ethanol compared to *Saccharomyces* species, due to which *Kluyveromyces* species do not grow during the final stage of must fermentation, leading to incomplete utilization of lactose in the prepared wines.

The 1:1 diluted wine showed significantly ($p<0.05$) higher values for total phenols and total esters than 2:1 and 3:1 dilution, as fruit contains more phenols and esters compared to whey. Due to this, DPPH and ABTS values of 1:1 diluted wine are higher than

other diluted wine samples. The dilution of juices before wine preparation resulted in a reduction in the concentration of volatiles, possibly due to the dilution of precursors derived from juice that is produced from various microbial metabolic pathways such as glycolysis (Gardner et al. 2020). Schelezki et al. (2020) prepared wine from Shiraz juice and mentioned that the diluted juice wine has significantly ($p<0.05$) lower volatiles compared to undiluted juice wine. The wine prepared from wild apricots has 253.6 mg/L of total phenol and 135.4 mg/L of total esters (Shyam and Joshi, 2019). Finicelli et al. (2019) reported that polyphenols of wine are bioactive compounds that have many health benefits in humans. There was a significant ($p<0.05$) decrease in the ash content of wines as the dilution rate increased. This may be due to the higher mineral content of apricot fruit compared to whey. There was a notable increase in the lightness (*L**) value as dilution increased, suggesting that the clarity of the wine improved. The yellowness (*b**) value was significantly ($p<0.05$) higher in the 1:1 diluted wine sample due to the high proportion of apricot fruit which gave the wine a more yellow color compared to other diluted wines, which exhibited a light golden yellow color due to a higher proportion of whey and less apricot fruit. In contrast, redness (*a**) values significantly ($p<0.05$) decreased due to an increase in the treated whey portion in the more diluted wines. Papun et al. (2024) also noted that the fermentation of apricot juice also affects the color values of the juice.

Effect of different percentages of yeast co-culture on the physico-chemical characteristic of the paneer whey-apricot wine

Yeast co-cultures of *Saccharomyces cerevisiae* and *Kluyveromyces marxianus* in 1:1 ratio was inoculated in the must in concentration from 5% to 10% and their effect on the final wine composition is shown in Table 3.6. Nardi et al. (2019) also noted that *S. cerevisiae* and *non-Saccharomyces* yeast give good quality kiwi wine. Borren & Tian (2021) reported that *non-saccharomyces* yeasts have low fermentation kinetic behavior and high sensitivity to ethanol due to which they cannot be used as only pure starter culture, for the preparation of a good quality wine. The yeast count of 8.65 ± 0.03 x log (CFU/mL) was used as inoculum in the wine preparation, which gives a good fermentation rate. Kosseva et al. (2016) also noted that an ideal concentration of 10^6 cells/mL should be used as inoculum in the "must" to produce good quality wine with a normal fermentation rate. A very low percentage of yeast slows the fermentation rate and negatively impacts wine quality. A high percentage of yeast inoculation increases the rate of fermentation and generates excess heat, potentially harming the alcohol-producing yeast cells. As the percentage of inoculum was increased in the must, there was a significant ($p<0.05$) increase in the fermentation rate from 0.656 to 1.027°B per day, affecting the compositional and physicochemical properties of the wine. Kushawah & Firdos (2022) noted that spontaneous fermentation in the preparation of wild apricot wine led to a slow fermentation rate and a gradual decrease in the TSS of wine, which resulted in a low alcohol content and adversely affected the overall quality of the wine. Fermentation was completed in 22.33 days with a 5% yeast co-culture, 17.67 days with a 7.5% co-culture, and 15.67 days with a 10% yeast co-culture. The wine made with a 10% yeast co-culture produced the highest ethanol, 13.69%, while the lowest was in the wine produced with a 5% yeast co-culture, 12.74%. The wine produced with a 10% yeast co-culture had the highest ethanol content (13.69%), whereas the lowest ethanol level (12.74%), was produced in the wine made with a 5% yeast co-culture. There was a significant ($p<0.05$) decrease in total solids, total soluble solids, reducing sugar, and total sugar as the percentage of inoculum increased in must for wine preparation. This may be due to more yeast utilizing a higher quantity of sugar during fermentation. Zhang et al. (2024) also mentioned that reducing sugars of the wines fermented by co-fermentation were dramatically reduced. *Non-saccharomyces* wine yeasts were considered detrimental in winemaking because of their ability to

Table 5: Comparison of sensory scores of 1:1, 2:1, and 3:1 diluted wine

Parameters	Maximum Scores	Diluted Wines		
		1:1	2:1	3:1
Appearance	2	0.83±0.06^c	1.73±0.07^a	1.48±0.11^b
Color	2	1.1±0.1^c	1.7±0.08^a	1.22±0.08^b
Aroma & Bouquet	4	3.69±0.08^a	3.41±0.1^b	1.98±0.1^c
Acetic Acid (Vinegary)	2	1.75±0.06^a	1.74±0.04^a	1.74±0.05^a
Total Acidity	2	0.54±0.05^c	1.74±0.07^a	1.34±0.06^b
Sweetness	1	0.6±0.1^b	0.72±0.02^a	0.45±0.04^c
Body/Mouthfeel	1	0.27±05^c	0.77±0.03^a	0.62±0.02^b
Flavor	2	0.84±0.05^c	1.72±0.02^a	0.94±0.04^b
Bitterness & Astringency	2	1.75±0.06^b	1.87±0.03^a	1.74±0.04^b
General Quality	2	0.45±0.05^c	1.83±0.01^a	1.15±0.05^b
Total Score	20	11.82±0.38^c	17.32±0.33^a	12.66±0.2^b

Mean±SD (n=20).

a,b,cMean values with different superscripts within the rows differ significantly ($p<0.05$)

produce undesirable compounds, such as acetic acid and acetaldehyde (Benito et al. 2019, Ciani et al. 2010).

Ethanol is the main stress factor faced by the yeast cell during fermentation. During fermentation, an increased concentration of ethanol inhibits the viability and growth of yeast (Saini et al. 2018). Some yeasts such as *S. cerevisiae* can tolerate 15–20% ethanol (Saini et al. 2018). A significant ($p<0.05$) decrease in titratable and volatile acidity was observed with an increase in the percentage of yeast from 5% to 10%, and there was a significant ($p<0.05$) reduction in the pH of 5% and 7.5% yeast fermented wine. While it was not significant ($p>0.05$) in 10% yeast fermented wine. The 5% yeast fermented wine has significantly ($p<0.05$) higher acidity compared to 7.5% and 10% yeast fermented wine samples. The organic acids present in fruit wine can inhibit the growth of harmful bacteria to a certain extent (Gutiérrez-Escobar et al. 2021). Acetic acid is the main component of volatile acidity. Ribereau-Gayon et al. (2006) indicated that it is not easily detected on the palate in normal wine if its concentration is below 0.72 g/L, but above this level, wine aroma starts to be affected and flavor starts to deteriorate (Mangani et al. 2020). Methanol was not detected in any prepared wine sample which showed the hygiene maintained during the wine preparation and the product is safe.

There was no significant difference in the total phenols, which showed that yeasts used in the wine preparation did not produce or consume the phenolic content of the wine. Mangani et al. (2020) reported that *S. cerevisiae* adsorbs the phenolics from its cell wall and reduces the phenolic content of wine which adversely affects the quality of the final wine. In one study, it was mentioned that the co-fermentation by *S. cerevisiae* and *non-saccharomyces* yeasts significantly increased the flavan-3-ols content in the kiwi wine, due to the breakdown of plant cell walls by yeasts, which releases phenolic compounds in the wine (Mirmahdi et al. 2024). While the other study said that, wild apricot wine contains a significantly higher amount of total phenols (167.7 mg/L) when fermented by *Saccharomyces cerevisiae* compared with 70 mg/l in naturally fermented wild apricot wine (Kushawah and Firdos., 2022). Moreover, a lower ethanol content corresponded also a lower content of both free anthocyanins and flavan-3-ols, key compounds for wine quality possessing antioxidant properties (Mangani et al. 2020). A similar trend was observed in the DPPH and ABTS assays of the wine, indicating that total phenols are the primary contributors to its antioxidant properties. Zhang et al (2024) also reported that antioxidant activities were positively correlated with the total phenolic content of the wine. Total esters didn't show any significant difference as the concentration of the yeast co-culture increased from 5% to 10%. This showed that the yeast co-cultures used in the preparation of wine did not affect the ester content of the wine. The yeast co-cultures did

Table 6: Effect of different levels of yeast co-culture on the physico-chemical properties of wine

Parameter	Yeast co-culture		
	5%	7.5%	10%
Fermentation Rate (°B/24h)	0.66±0.02^{c}	0.89±0.03^{b}	1.03±0.04^{a}
Complete Fermentation (days)	22.33±0.57^{a}	17.67±0.57^{b}	15.67±1.15^{c}
Ethanol (%)	12.74±0.03^{b}	13.52±0.06^{a}	13.69±0.02^{a}
Methanol (%)	*BLQ	*BLQ	*BLQ
Total Soluble Solids (°B)	9.13±0.06^{a}	8.63±0.15^{b}	8.27±0.15^{c}
Total Solids (%)	9.24±0.05^{a}	8.92±0.08^{b}	8.61±0.06^{c}
Titratable acidity (% maleic acid)	0.445±0.003^{a}	0.44±0.003^{ab}	0.431±0.008^{b}
Volatile Acidity (% acetic acid)	0.02±0.001^{a}	0.02±0.001^{a}	0.017±0.001^{b}
pH	4.54±0.03^{b}	4.58±0.01^{b}	4.65±0.02^{a}
Reducing sugars (%)	3.59±0.03^{a}	3.36±0.02^{b}	3.2±0.06^{c}
Total sugars (%)	3.73±0.06^{a}	3.51±0.02^{b}	3.4±0.04^{c}
Total phenols (mg GAE/L)	274.94±1.45^{a}	272.67±2.58^{a}	276.54±5.26^{a}
Total esters (g/L of absolute alcohol)	122.73±1.55^{a}	124.07±3.16^{a}	125.93±1.89^{a}
DPPH (% inhibition)	91.51±0.82^{a}	91.73±0.494^{a}	91.52±0.33^{a}
ABTS (%inhibition)	96.56±0.3^{a}	96.81±0.48^{a}	96.75±0.47^{a}
Ash content (%)	0.534±0.01^{a}	0.544±0.013^{a}	0.553±0.01^{a}
Color Values			
*L**	73.13±0.04^{a}	73.06±0.06^{a}	73.11±0.06^{a}
*a**	5.69±0.05^{a}	5.76±0.09^{a}	4.96±0.08^{b}
*b**	53.01±0.4^{a}	52.93±0.18^{a}	53.47±0.99^{a}

Mean±SD (n=3); GAE Gallic Acid equivalent; BLQ, Below Limit of Quantification; *BLQ (<0.05), BLQ (<0.1).
^{a,b,c} Mean values with different superscripts within the rows differ significantly ($p<0.05$)

not significantly influence the ash content of the wine, as no notable changes were observed. The lightness (L*), redness (a*), and yellowness (b*) values of wine fermented with various percentages of yeast co-cultures showed no significant changes. However, Zhang et al. (2024) reported that *non-saccharomyces* yeasts produced metabolites during alcoholic fermentation that influence the color of the wine. No significant difference was detected in color intensity (Mangani et al. 2020). Kushawah & Firdos (2022) reported that a 5% concentration of *Saccharomyces cerevisiae var. ellipsoideus* was optimum for the preparation of good quality wild apricot wine. In contrast, the results above suggest that a 7.5% yeast co-culture produced a high-quality wine with an optimal level of ethanol.

Sensory evaluation of the wine as affected by blending paneer-whey and apricot pulp

The sensory evaluation of various diluted wine samples, including 1:1, 2:1, and 3:1 dilution, was performed by 20 semi-trained judges utilizing the Davis 20-point scorecard (Langstaff, 2010). The obtained sensory scores are presented in Table 5. The appearance and color of wine provide the first impression of its quality and significantly impact all other sensory parameters (Ailer et al. 2020). The appearance and color score for the 2:1 dilution was significantly ($p < 0.05$) higher compared to the 3:1 and 1:1 dilutions. This difference may be due to the very dark yellow color of the 1:1 dilution, which was unappealing to the judges, while the 3:1 dilution exhibited a light-yellow color due to the lower proportion of apricot fruit juice used during must preparation. Teng et al. (2020) also reported that the dilution of high-sugar juice with water during the must preparation before fermentation reduces the color values of the final wine. Apricot fruit contributes to a yellow colour to the wine with a slight greenish tinge contributed by whey. The results of the present study revealed that as the concentration of whey increased in the wine sample, the yellow colour got diluted and greenish colour intensity increased. However, the colour of the *paneer* whey-apricot wine remained yellow (Fig. 3). Wine aromas will play a very important role in wine acceptability and directly affect consumer preferences (Caissie et al. 2023; Sáenz-Navajas et al. 2016). Canon et al. (2022) mentioned that volatile compounds contribute to the aroma of the wine. The aroma and bouquet values were significantly ($p<0.05$) higher for 1:1 diluted wine, possibly due to a higher percentage of apricot fruit compared to 2:1 and 3:1. Similar to colour, the aroma of the *paneer* whey-apricot wine was also affected by the aroma of apricot fruit pulp, which enhanced the wine's sensory quality and was distinctly different from whey wine (without any apricot wine). The sensory analysis revealed that the wine samples containing a higher proportion of apricot pulp had a significantly higher intensity of fruit flavour and colour ($p<0.05$). Among the formulations, the 1:1 ratio achieved the highest aroma scores, followed by the 2:1 and 3:1 wine sample. Xynas et al. (2024) reported similar findings, noting that the odor intensity scores for undiluted wine were higher compared to diluted samples. However, the undiluted wine was less acceptable sensory-wise because the aroma was perceived as "too high". Garbay et al. (2024) reported that grape varieties impart fruity aromas to red wines, which positively enhanced the sensory acceptability of red wines. Higher levels of acetic acid are not desirable in good-quality wine, as they form when the must is contaminated by spoilage microbes during preparation. The high scores achieved by all the wines, in the present study, indicate that proper hygiene practices were followed throughout the winemaking process, which minimized the production of acetic acid. This is crucial because acetic acid can give the wine a vinegar-like flavor, which is not acceptable for good-quality wines.

Fig. 3 Visual colour of *paneer* whey-apricot wine as affected by dilution ratios

The 1:1 diluted wine exhibited the highest total acidity, attributable to the greater acidity of apricot fruit compared to *paneer* whey, resulting in the lowest overall score among the wine samples. Conversely, the 2:1 diluted wine received the highest scores for total acidity, indicating that its acidity fell within the sensorily acceptable range. Canon et al. (2022) reported that non-volatile compounds play a significant role in the taste of wine, impacting both its quality and consumer acceptability. The primary taste profiles include sweet, bitter, sour, and salty (Xynas et al. 2024). The sweetness of the 2:1 diluted wine was significantly ($p<0.05$) higher than other samples. The lower score for the 3:1 sample may be due to the higher sugar consumption by the yeast. At the same time, the sweetness of 1:1 diluted wine could be affected by the higher amount of fruit juice in the must. The mouthfeel and texture of wine are a complex combination of taste and mouthfeel sensations (Canon et al. 2022). The 1:1 diluted wine was very thick, resulting in a significantly ($p<0.05$) lower score compared to the 2:1 diluted wine, which had a perfect mouthfeel. Conversely, the 3:1 diluted wine had a very thin mouthfeel due to the reduced amount of fruit juice used in its preparation. Tannins also contribute to the texture and mouthfeel of wine (Schelezki et al. 2020). Xynas et al. (2024) reported that dilution of must with water to decrease the ethanol percentage in the final wine also affects the texture and mouthfeel of the wine negatively. Wines

always have a range of viscosity and consistency values varying with the type of wine, which directly contribute to their sensory acceptability. Sweet wines generally have a higher percentage of sugars, which confers a higher viscosity thereby consistency compared to dry wines (wines having very little or no residual sugars) (Yanniotis et al. 2007). In the present study, *paneer* whey–apricot wine contained substantial amount of sugars and ethanol, which might have led to an increase in the viscosity compared to water (1 mPa·s) and contributed to the wine's overall consistency.

The flavor of the 2:1 diluted wine was considered acceptable and significantly ($p<0.05$) better than that of the 1:1 and 3:1 dilution. This may be due to the higher juice concentration in the 1:1 diluted wine, which results in a very intense flavor that is undesirable in wine. In contrast, the 3:1 diluted wine had a much lighter fruit flavor due to the reduced amount of fruit juice in the must preparation, leading to decreased acceptability. Previous studies also showed that dilution of must with water decreases the taste and flavor of the final wine (Petrie et al, 2019; Piccardo et al. 2019; Schelezki et al. 2018). The bitterness and astringency scores were significantly ($p<0.05$) higher for the 2:1 diluted wine, while the 1:1 and 3:1 diluted wine received lower scores. Xynas et al. (2024) reported that total tannins and total phenolic will also contribute to the astringency of the wine. The overall quality scores indicated that the 2:1 diluted wine was considered good and sensorily acceptable. Furthermore, the 2:1 diluted wine received significantly higher total scores ($p<0.05$) than the 3:1 diluted wine, which in turn scored significantly higher ($p<0.05$) than the 1:1 diluted wine, indicating that the 1:1 diluted wine was not sensorily acceptable.

Conclusion

The apricot fruit and treated *paneer* whey were used to prepare wine. It was apparent that variations in the pectinase treatment, dilution ratio and yeast co-culture percentage affect the physico-chemical qualities of prepared wine. The apricot fruit has a high amount of fiber which holds the soluble solids, so three different pectinase treatments were given, and 0.5% pectinase treatment was optimized based on the juice yield and other parameters. The three dilution ratios of apricot pulp by using treated whey were analysed and based on the ethanol production and sensory scores, the 2:1 diluted wine was optimized, which gives the desirable wine with good sensorily acceptability. The effect of three different percentages of yeast co-culture on the physicochemical properties of the wine was analyzed and based on the ethanol percentage in the final wine, 7.5% yeast co-culture was optimized. It is concluded that *Paneer* whey-apricot wine with 0.5% pectinase level, 2:1 dilution ratio, and 7.5% yeast co-culture gives a high-quality wine with good sensory acceptability. Future studies may be taken with different whey based on their sources and types, for various whey-fruit wine production to reduce wastage of whey and fruits and provide more opportunities for introducing whey into the food chain.

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