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Production, Quality evaluation & Optimization of mixed fruit vinegar from various fruits (Apricot, Bael, Date and Fig)

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Abstract:
Nowadays, there is a growing interest in foods and drinks that have functional and healthful qualities, particularly those that promise to avoid chronic illnesses. Vinegar and fermented drinks are among the goods with enhanced attributes. The primary objective of vinegar production is to prevent fruit loss or deterioration, which can be used for food preparation and preservation. The present study aimed to characterize vinegar of fermented fruits, namely date, fig, apricot, and bael following a double fermentation. In this study physico-chemical, biochemical, and sensory properties of mixed fruit vinegar were investigated. The manufactured vinegar was examined, and TSS, acidity, pH, reducing sugar, total sugar, and ascorbic acid were: 6ºBx, 0.84%, 4.03, 7.76mg/ml, 10.11mg/ml, and 28.37mg/100ml. The antioxidant, carotenoid, and phenolic content were 53.81%, 2.83 mg/ml, and 99.29 mg GAE/mL. The phytochemicals, terpenoids, cardiac glycosides, alkaloids;0.85 mg/mL, flavonoids;2.98 mg QE/mL, and tannins;1.34 mg TAE/mL. The mineral contents (mg/ml) were as follows: K;42.62, Na;37.71, Ca;11.11, Mg;13.48, Mn;2.61, Cu;0.65, Fe;9.75, and Zn;3.44. The participants' average ratings for color, aroma, taste, flavor, and overall acceptability were 8.41, 7.75, 7.25, 8.13, and 8.08. The findings of study indicate that antioxidants, minerals, phenols, and carotenoids present in mixed fruit vinegar are very beneficial to human health.

Keywords: chemical, characterstics, contents, fermentation, fruit vinegar, analyses.

1. Introduction

Vinegar is an ancient fermented food that has been consumed by man since the Babylonian period. Historically, speaking vinegar has existed since about 6000 BC. The word "vin" means wine and " aigre'' means sour. It was originally made from wine. The Holy Bible mentions it and Hypocrites used it as a health remedy (Solieri and Giudici, 2009). It adds flavor to vegetable and meat products (Budak et al., 2014) and can be used as a condiment for salad dressings, sauces, such as tabasco, and tomato products, such as ketchup, mustard, and spices. As a result, a sizable amount of vinegar is marketed as such for domestic use. Natural vinegar is a superior food additive (Hailu et al., 2012) and it has been considered a safe and healthful beverage (Solieri and Giudici, 2009), made from any sugary material like apples, pineapple, bael, pomegranate, mango, grapes, palm juices, and molasses. However, traditional balsamic vinegar is a natural product produced from grape must which contains polyphenols with high antioxidant activity Tagliazucchi et al., 2010). Seasoned vinegar is create or make from brewed vinegar, by adding variety of condiments and spices which is then used as salad dressing. The FDA (Food and Drug Administration, USA) states that vinegar, a sour solution, is made from alcohol and the sequential acetic fermentation of sweet and starchy substrates. It includes at least 4 grams of acetic acid per 100 cubic centimeters. The submerged culture technique and the Orleans process, sometimes known as the generator process, were earlier methods for producing vinegar. Today, commercial vinegar manufacturing uses the developed fast technique and submerged culture technology. Before being bottled, vinegar may undergo additional processing such as filtering, clarifying, distillation, and pasteurization once the substrate is converted to acetic acid. Fruits are nutritionally rich in various components such as vitamins, phenols, terpenoids, antioxidants, and various minerals etc. (Xiang et al., 2019) hence, the vinegar produced from these fruits would also be indirectly rich in various nutrients (Luzon-Quintana et al., 2021). Typically, fruit wines are used to make vinegars without the addition of any flavorings. Fruit vinegar and malt liquor are examples of substances that possess these qualities. Due to their high sugar content and accessibility, fruits are a popular crop worldwide, and their juices are the preferred substrate for natural vinegar (Tewari et al., 1991). These fruit vinegars are considered superior than the other vinegar in term of sensory and nutritional quality (Marques et al., 2010).

However, over the last few years, the motive of diet has changed dramatically; food is increasingly called upon to grant physiological supplementary benefits in terms of health management and prevention of disease (Mann et al., 2007). The latest changes in lifestyle food (increased intake of fast food, caloric consumption (glucose), stored food, and very low physical activity), among others, are major elements facilitating the installation of metabolic disorders (Ousaaid et al., 2020). So that the secondary metabolites present in various natural products such as fruit vinegar have strong antioxidant activity that functions to prevent oxidative stress (Stagos, 2019). Several studies exhibited many benefits of vinegar consumption such as glucose-lowering effect in patients with glucose abnormalities, improved insulin sensitivity, decreasing the glycemic index of carbohydrate food for people with and without diabetes, antihyperlipidemic, hepatoprotective effect, and modulation of lipid peroxidation (Kavishankar et al., 2011). The four fruits (Apricot, Date, Bael, and Fig) which are used for mixed fruit vinegar production represents high sources of nutrients with functional features that possess antioxidant activity, antidiabetic, and antimicrobial properties as well as preventing cardiovascular disease. These advantages make this vinegar different from other vinegar. Therefore, this study was carried out to produce and assess the quality of mixed fruit vinegar produced from fruits (Apricot, Date, Fig and Bael). This will help to reduce high rate of post-harvest losses and also provide information on diversification and utilization of fruits.

2. MATERIALS AND METHODS:

The present investigation entitled "Production, quality evaluation & optimization of mixed fruit vinegar from various fruits" was carried out in the lab of Department of Biotechnology, School of Applied Science, Om Sterling Global University, Hisar during the year 2021-24.

2.1 Fruits

Fruits (Date, Fig, Apricot, Bael) were collected from the local fruit market at the time of harvesting, District Hisar, Haryana, India. Mature fruits of uniform size, well ripened were selected and washed with boiled water.

2.2 Juice extraction and must preparation

Remove the outer covering of fruits and eliminate the pits or seeds from the fruit with sterile knife. Extract the pulp and crushed with a mixer and then water was added to the pulp (1:2) to lower down its high acidity value. This water- pulp mixture was heated at 85ºC for 30 min (This operation not only prevents the browning of the finished product, but also allows the partial destruction of the vegetative forms of microorganisms that can alter the product over time) then it was filtered through muslin cloth or centrifuged at 4000 rpm for 15 min. Then resulting filtrate was weighed. For two (2) kg of fruit 500g each, three liters of juice was obtained from the fruits. The fruits juice was preserved with the addition of Potassium metabisulphite (KMS) @ 2000 ppm for further use.

2.3 Alcoholic fermentation

Before sowing for fermentation, the juices were concentrated with sugar. The initial sugar content of the fruit juices is determined by a refractometer; then, the initial TSS of the must was raised to different levels, viz.14ºBX, 16ºBX and 18ºBX by adding sugar syrup (sucrose). For better extraction as well as clarification of mash, add pectin esterase (0.3%) and DAHP (0.1%) to the mixed fruit juice. The pH of the fruit juice was also adjusted to 4 to 5.5 by adding lemon juice or tartaric acid (1g/L). The resulting juices packaged in sealed bottles were immersed in boiling water for 20 minutes and allowed to cool to at a room temperature. The fermentation of the prepared musts was carried out with adding yeast starter culture of *Saccharomyces cerevisiae* at a concentration of 5% in alcoholic fermentation at a temperature of 25-28ºC. The fermentation was allowed to continue for 2-3 weeks or until reaching a stable endpoint. Further on the basis of the rate of fermentation best treatment was selected for acetic acid fermentation.

2.4 Acetous Fermentation

After the completion of alcoholic fermentation, siphoning (racking) was carried out to separate the fruit-based beverage from the sediment. This process was repeated two-three times at 5-7 days interval to discard the deposited residues at the bottom. Then clarification and fining of the mixture by adding of gelatin/bentonite (0.3%), the mixture is stirred well and then allowed to settle atleast one week before final racking (Bentonite (0.04%) was applied prior to the last racking to get rid of any last remnants). Then, the clarified beverage were filled in sterilized glass bottles, corked and pasteurized at a temperature of 65ºC for 15-20 minutes. Once the fermentable sugar present in the juice was transformed into ethanol, the fermented juice was centrifuged for 20 min. The next fermentation is acetic fermentation carried out with *Acetobacter aceti* at a concentration of 7% and bottles were placed in the dark at 28-30ºC. Due to fast rate of fermentation the 16ºB was taken for acetous fermentation. The fermentation was allowed for 1-2 weeks. The entire process is shown diagrammatically in Fig. 1.

2.5 Bottling

After fermentation filter the juice using a tea strainer/muslin cloth. Filtered mixture were transfered to sealed bottles and allow for pasteurization by immersing the bottles in hot water at 65ºC for 20-25 min. SMS (sodium metabisulphite) (100 mg/ ml) was added as preservative before bottling for storage. Then analysed for various physico-chemical, biochemical and sensory characterstics.

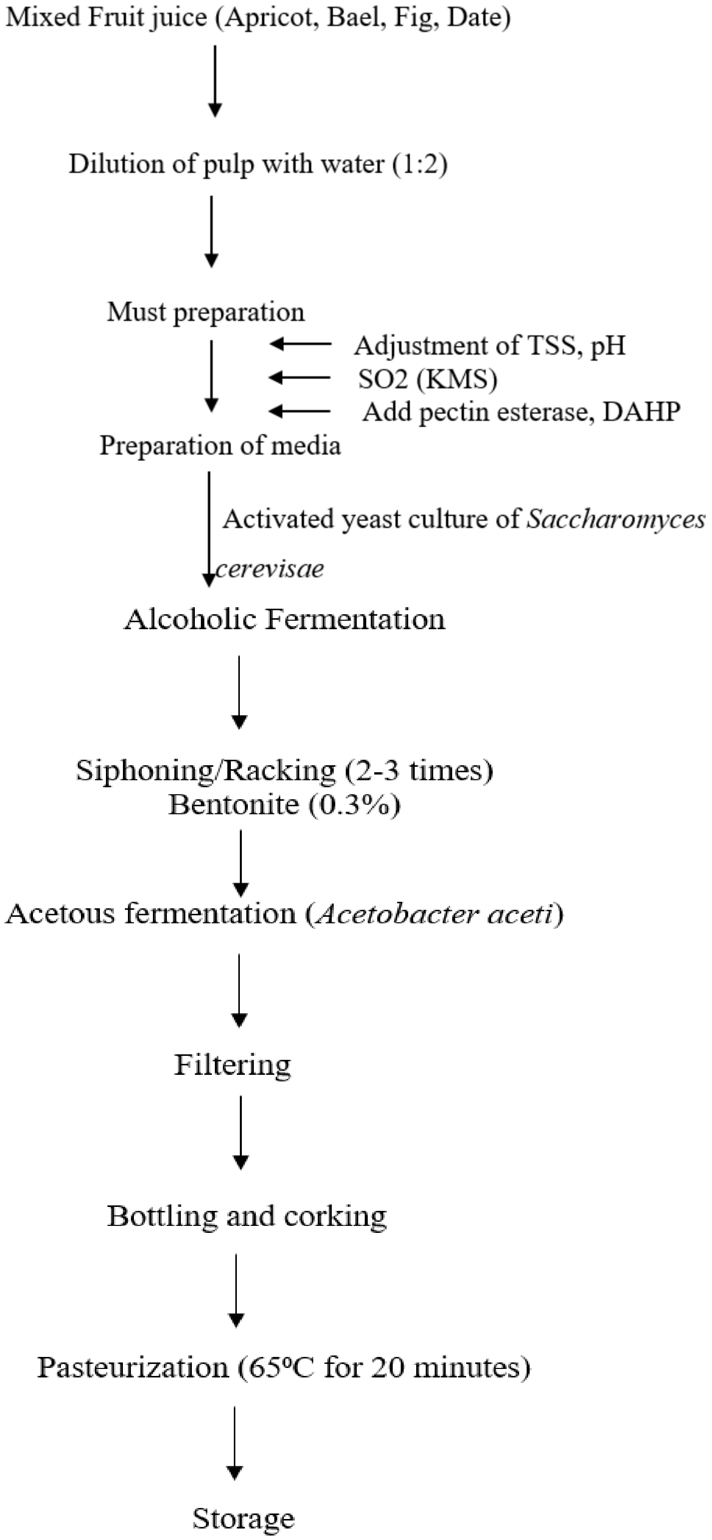

Fig. 1 Flow chart for the preparation of fermented beverage (mixed fruit vinegar) from mixed fruits

3. ANALYSIS OF MIXED FRUIT VINEGAR

3.1 DETERMINATION OF PHYSICOCHEMICAL ANALYSIS

Fruits were analyzed for various physical and chemical characteristics viz. weight, length, pulp recovery, color, TSS, titratable acidity, pH, total sugar, reducing sugar, ascorbic acid, phenols, carotenoids and antioxidant scavenging activity.

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3.1.1 Physical characterstics
The weight of fruits was taken with the help of physical balance in gm while diameter and length were measured with the venire caliper in cm. The color of fruit was recorded on a visual comparison basis. The pulp yield is the ratio of the fruit's edible portion, or pulp, to its total weight multiplied by 100. Pulp yield was calculated and expressed in percent (Sawale et al., 2018).

3.1.2 Chemical characterstics
The total soluble solids (TSS) were measured using Erma hand refractometer (0-32ºB) and results were expressed as degree Brix (ºBx). The readings were corrected by applying the correction factor for the temperature variation (Andrews, 1996). The pH of the juice was measured using a pH meter calibrated at pH 4.0 and 7.0 before each use. It was determined according to methods (International, 2000). Titratable acidity is determined by titrating the sample with a standard alkali solution (e.g., 0.1 N NaOH) using a suitable indicator (International, 2000). The rate of fermentation (RF) value was calculated by º Brix (Initial-Final)/day. The phenol-sulfuric acid method was used to measure the total amount of sugars. Reducing sugar was estimated by DNS method. Carotenoids were determined as per the method described by Sanusi and Adebiyi (2009). Total phenols were determined by the Folin-Ciocalteu procedure as described by Thimmaiah and Thimmaiah, (2004). Ascorbic acid content was measured by the iodine titration method. The antioxidant activity was measured using the DPPH (2,2-diphenyl-1- picrylhydrazyl) assay (Mahmud et al., 2020).

3.2 DETERMINATION OF BIOCHEMICAL ESTIMATION
The total flavonoid content, the aluminum chloride colorimetric method was employed (Ribarova et al., 2005); (Chang et al., 2002). Terpenoid test is also known as Salkowski test. A 2 mL of mixed fruit vinegar sample was mixed with 2 mL of chloroform. Then, 3 mL of concentrated sulfuric acid was carefully and slowly added along the sides of test tubes to form a layer. Terpenoids were detected by a reddish-brown coloring at the interface. The mineral content (K, Na, Ca, Cu, Fe, Mn and Zn) was quantified using atomic emission spectrometry (AES). For alkaloid estimation 5 mL of mixed fruit vinegar sample was mixed with 5 mL of 10% acetic acid in ethanol. The mixture was covered and allowed to stand for 4 hours. It was then filtered, and the filtrate was concentrated to one-quarter of its original volume by evaporation. Concentrated ammonium hydroxide was added dropwise to the extract until a precipitate formed, indicating the presence of alkaloids. The precipitate was washed with dilute ammonium hydroxide and then dried and weighed to determine the alkaloid content (Oguyemi, 1979). Tannin was determined by Folin–Ciocalteu method. In order to modify the phosphotungstic-phosphomolybdic reagent, lithium sulfate and bromine were added (Barlocher & Graca, 2020). Cardiac glycosides test is also known as Keller-Killiani Test. It was carried out using the methodology outlined by Ayoola et al., 2008.

3.3 SENSORY ANALYSIS OF MIXED FRUIT VINEGAR
Mixed fruit vinegar's sensory evaluation was carried out using a nine-point hedonic scale rating test (Chude et al., 2018). The organoleptic evaluation for assessing the color, flavor, taste, overall acceptability, and aroma of sample were conducted by a panel of 10 people. The specimen of evaluation card is shown in Appendix A.

4. RESULTS AND DISCUSSION
4.1 Physical characteristics of fruits
The results on Table 1 describe the physical characteristics of four fruits (Fig, Bael, Apricot, and Date). The brown Date fruit weighed between 10 and 12.6 g and was 3 to 6 cm in length. Its pulp recovery was 72.9% and its pulp weight was 7-8g. The observations made above on each of the physico-morphological characteristics closely match those published by Mohamed et al., (2023). The pulp of the Figs was pinkish, while the fruit itself was crimson on the outside. The average fruit weight and length were found to be 27.23 g and 3.2 cm, respectively. Fruit pulp recovery was determined to be 78.1% and pulp weight was 20.22g on average. The physico-morphological parameters mentioned above closely match the findings of Khapre and Satwadhar, (2011). The Bael fruit weighed 1114g, was 6-11cm in length. The value for same parameter was recorded to range between 1063 to 2950 g (Prasad & Singh, 2001) and to be around 650 to 764 g (Kaushik et al., 2000). Results implied that yellow and green was dominant in the Bael, with a light yellow pulp. Its pulp recovery was 55.51% and its pulp weight was 67g. The observations made above on each of the physico-morphological characteristics closely match those published by Amarjeet Kaur and Manoranjan Kalia, (2016).
The pulp of Apricots was orange while the fruit itself was orange-yellow sometimes reddish this is caused by the carotenoids that they contained. Fruit weighed an average of 26.7 g and measured 4.49 cm in length. The obtained fruit weight results were comparable to a study conducted in Turkey, because all Turkish Apricot cultivars have a relatively small-to medium fruit weight changing from 25 g to 40 g (Asma and Ozturk, 2005; YILMAZ et al., 2012). Fruit pulp recovery was determined to be 81.4% and its average pulp weight was 28.73g.
The results on Table 2 represents the chemical characterstics of mixed fruit vinegar include TSS, titratable acidity, pH, total sugar, reducing sugar, ascorbic acid, phenols, carotenoids and antioxidant scavenging activity. The TSS of mixed fruit vinegar was found to be 6ºBx respectively which was normal on range. TSS of initial vinegar was maintained at 14ºBx, 16ºBx, and 18ºBx by using required amount of sugar. The TSS fluctuated throughout the fermentation periods.

The same trend was found in (Chalchisa & Dereje, 2021). In a study by Joshi et al., (2019), the initial TSS was maintained at 14ºBx and the final TSS was found to be 4ºBx for the production of apple cider vinegar which was close to our study. According to Moisescu and Antoce, (2022) TSS was ranged in between 13-15ºBx, TSS of mango vinegar was close to 12ºBx (Adebayo-Oyetoro et al., 2017). In the study of total brix values of the sample was ranged between 1.60-27.80ºBx (Ezemba et al., 2021). The 10.11 mg/ml of total sugar in mixed fruit vinegar was found to be normal, which is closely linked to Sharma et al., (2017)'s research, which examined the phytochemical and antioxidant activity of pomegranate and wild Apricot separately. The finding of Chauhan P, (2016) on studies on natural and inoculated alcoholic fermentation of Apricot for vinegar production is similar to total sugar results. According to Imrak et al., (2017), sucrose was the predominant sugar in Apricot cultivars cultivated in the Mediterranean region. According to Su et al., (2020), , the primary sugar in Apricot fruits was sucrose, which was followed by fructose and glucose. The reducing sugar of prepared mixed fruit vinegar was found to be 7.76mg/ml. The reducing sugar of Fig fruit varieties varies from 12.16-28.78g/l (Moisescu and Antoce, 2022), wild Apricot 1.86-2.14% Chauhan P, (2016), Fig fruit 14.65% (Khapre and Satwadhar, 2011), Date fruit 15.30% (Shukla et al., 2020). The reducing sugar on vinegar was observed to be decreasing due to the activities of *Saccharomyces cerevisiae* at room temperature.
The pH of mixed fruit vinegar was found to be 4.03 respectively. This values are close to the value reported by Moisescu and Antoce, (2022) for Fig vinegar, (Hamden et al., 2022) for Date vinegar, (Akarca et al., 2020) using traditional method for Date vinegar, (Panda et al., 2014) for Bael wine, (Adebayo-Oyetoro et al., 2017) for mango vinegar. The United States Food and Drug Administration (FDA) require that vinegar should contain at least 4% acidity, which is similarly given in Turkish Standards (Anonymous, 2004). The decrease in initial pH value of must inhibited metabolic activities of contaminated bacteria during vinegar fermentation. The growth of fruit vinegar yeast was therefore facilitated. Furthermore the lower pH 4.03 of the vinegar is highly favourable for the stability of the polyphenols as they are known to autooxidize with increase in pH (Mochizuki et al., 2002). The acidity of prepared vinegar was increased as fermentation time increased (Prisacaru et al., 2021). Initially, the acidity of mixed fruit vinegar was maintained at 0.16% which increased and reached upto 0.84% at the end of the period respectively. The acids present are largely responsible for the tart or sour flavor. According to Heikefelt, (2011), the acidity increased during fermentation, as expected when ethanol was converted to acetic acid by the bacterial culture. Similarly Ezemba et al., (2021) the acidity of mixed fruit vinegar was ranged from 0.50% to 1.19% which was quiet closed from our study. According to Ousaaid et al., (2021) acidity of apple vinegar was 0.67% to 0.79, pomegranate vinegar's acidity ranged from 0.97% to 0.99%, (Bouazza et al., 2016) which was in line with our findings. The change in the concentration of acidities supported the report of Thoukis et al., (1965) which stated that there are changes in the organic acid compositions of fermented medium during alcoholic fermentation by yeast.
The ascorbic acid content of mixed fruit vinegar was 28.37mg/100ml. Further, the vinegar was found to be a good source of vitamin C, highlighting the nutritional significance of fruits. According to S.K. Pandaa, (2013) the ascorbic acid content was recorded as 80mg/ml. Further, the highest (10.83 mg/100g) ascorbic acid content was recorded in Apricot fruit vinegar Chauhan P, (2016), 4.56mg/ml and 43.46 mg/100ml for orange and Date fruit (Swati Shukla, 2020), Ascorbic acid content of Fig fruit was 13.26mg/100g (Satwadhar, 2010). That significant difference was recorded in ascorbic acid content of different fruits prepared using different initial sugar concentration, type of fermentation and with or without enzymes. The total phenolic content in mixed fruit vinegar was 99.29 mg GAE/mL. A high concentration is a sign of highly aged vinegars since gallic acid in vinegar arose with age (Garcia-Parrilla et al., 1997). Nonetheless, it was discovered that the total phenolic content of wild Apricots in Turkey ranged from 34.2 to 52.8 mg GAE/100 g (Gecer et al., 2020). Carotenoid content of mixed fruit vinegar was 2.83 mg/ml. According to Ruiz et al., (2005), a variety of Apricot cultivars in Spain had a total carotenoid level ranging from 1.5 to 16.5 mg/100 g. It ranged from 0.5 to 9.5 mg/100 g among Apricot varieties in Israel, according to Shemesh et al., (2017). Gecer et al., (2020) found that the total carotenoid concentration of wild Apricots in Turkey ranged from 1.1 to 12.5 mg/100 g. Depending on the amount of carotenoids present, the fruit's color can range from yellow to orange (Fratianni et al., 2018); (Soorbrattee et al., 2005). The antioxidant activity of the mixed fruit vinegar was 53.81%. The mean total antioxidant of vinegar samples were determined to be 10300.00±671.43 Teq (ml/L) (Akarca et al., 2020). In their study, Bakir et al., (2016) determined that the total antioxidant values of grape and apple cider vinegar were 1624±244 and 1087±149 Teq (ml/L), respectively. There are differences between the values obtained as a result of our study and the results obtained due to the fact that vinegar is rich in carotenoids, phytosterols, and bioactive components and that total antioxidant values are higher. From our study it is envisaged that the antioxidant activity of the vinegar was attributed from the cumulative contribution of higher concentration of polyphenols, β-carotene pigments and other bioactive compounds present in the fruit.

4.2 Optimization of parameters during alcoholic and acetic fermentation of mixed fruit vinegar

Vinegar typically produced by double fermentation. In the first fermentation, the fruit juices are fermented alcoholically by the yeast *Saccharomyces cerevisiae*. This is followed by an acetic fermentation using acetic bacterial strains. During the process of fermentation various parameters were changes with time like pH, TSS, and acidity. There was a significant difference in the pH of fruits must (Apricot, Date, Fig and Bael) after alcoholic fermentation which was shown in Figure 2. The pH values of fruit must prepared from different treatments were significantly different from

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each other. The pH values ranged between 4.32 to 4.74 which shown in table 3. The highest pH value (4.74) was recorded in 18ºBx than in 16ºBx and lowest in 14ºBx after alcoholic fermentation of mixed fruit juice.

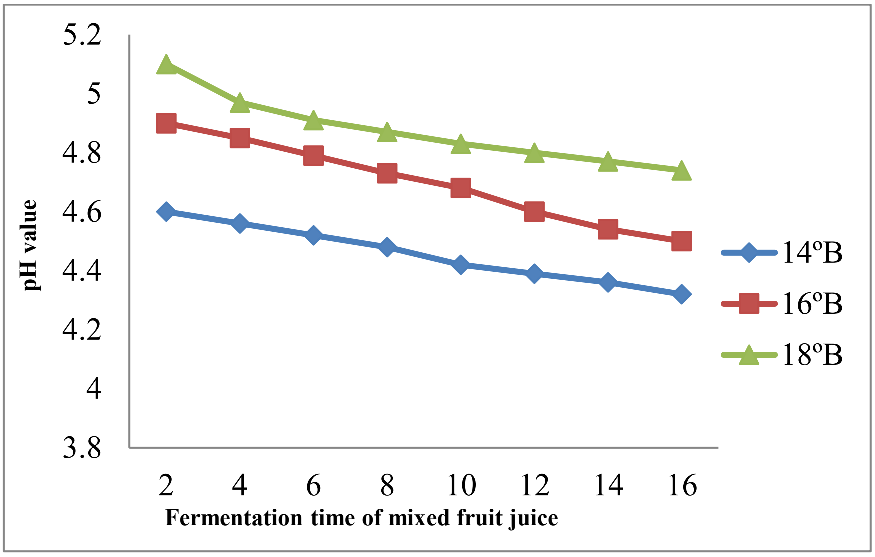

Fig. 2 Effect of pH on different TSS level (14, 16 and 18ºB) after alcoholic fermentation of mixed fruit juice

Due to fast rate of fermentation the 16ºBx was taken for acetous fermentation whose initial pH was 4.5 and after acetous fermentation the pH of mixed fruit vinegar was found to be 4.03 (Fig 3). pH was change day by day with noticeable variations. The mixed fruit vinegar's pH decreased due to its total or organic acid content (Kang et al., 2020).

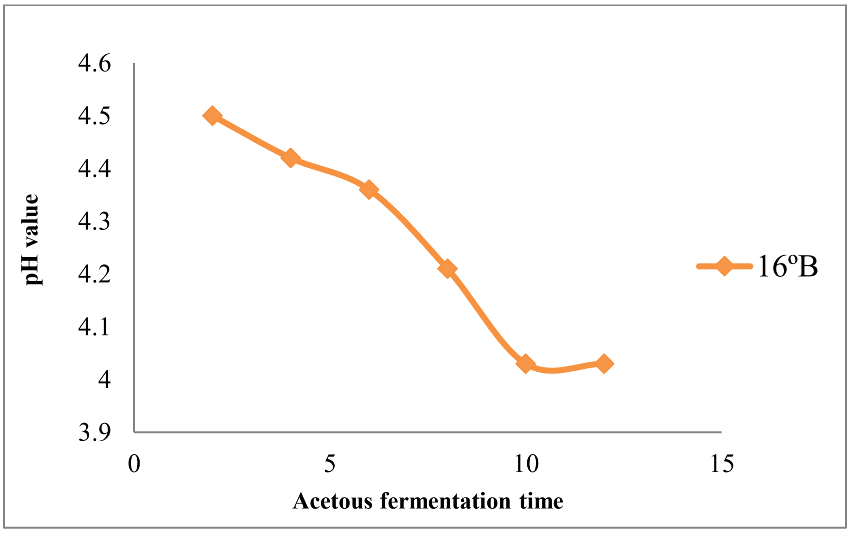

Fig. 3 Evolution in pH of mixed fruit vinegar during acetous fermentation

The fermentation behaviour of fruits (Apricot, Date, Bael, and Fig) shows reduction in total soluble solids. In inoculated fermentation, minimum reduction in total soluble solids (TSS ºBx) was recorded in treatment prepared with 14ºBx initial sugar concentration, with pectinase enzyme. There was a fast reduction in total soluble solids (0.43%) with 16ºB initial sugar concentration with pectinase enzyme and slow reduction in (TSS ºBx) along with the low rate of fermentation in 18ºBx as compared to 16ºBx but faster than 14ºBx in alcoholic fermentation shown in table 4. Until 4 days, the pattern remained the same but after 4th day it changed clearly, and followed by stabilization after 15th day (Fig 4).

Furthermore, the varying concentrations of additives and the pectin esterase enzyme are the cause of the differential behavior of the fermentation rate under the same fermentation conditions. When these additives interact in varying amounts, the fruit must's fermentation behavior varies, which impacts the rate of fermentation as well as other physicochemical properties (Joshi et al., 1990); (Joshi et al., 2012). Therefore, a high rate of fermentation had the lowest total soluble solids, which may be because the enzyme-containing must was more fermentable, which may have helped release fermentable sugar from the pulpy substance of enzyme action (Joshi et al., 2013).

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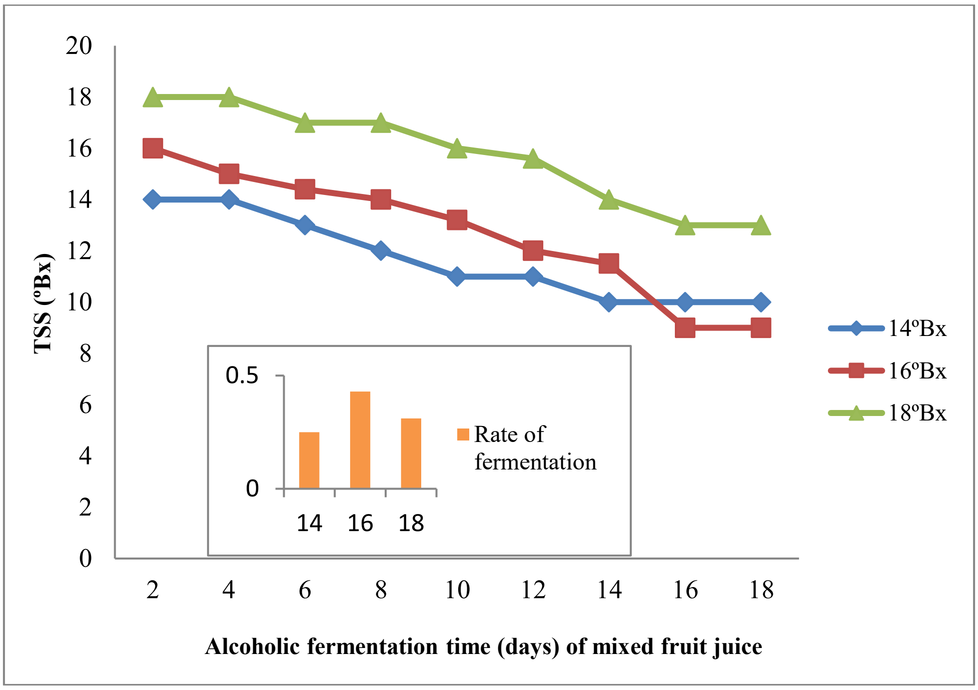

Fig.4 Comparison of fermentation behavior and rate of fermentation (RF) of fruit musts (Date, Apricot, Fig, and Bael) at different brix, fermented with starter culture of *Saccharomyces cerevisiae*

Due to fast rate of fermentation, the 16ºBx was taken for acetous fermentation whose initial brix was 9ºBx. After acetous fermentation of mixed fruit juices the final TSS (ºBx) of mixed fruit vinegar was found to be 6ºBx which was shown in fig 5. There was fast reduction in total soluble solids.

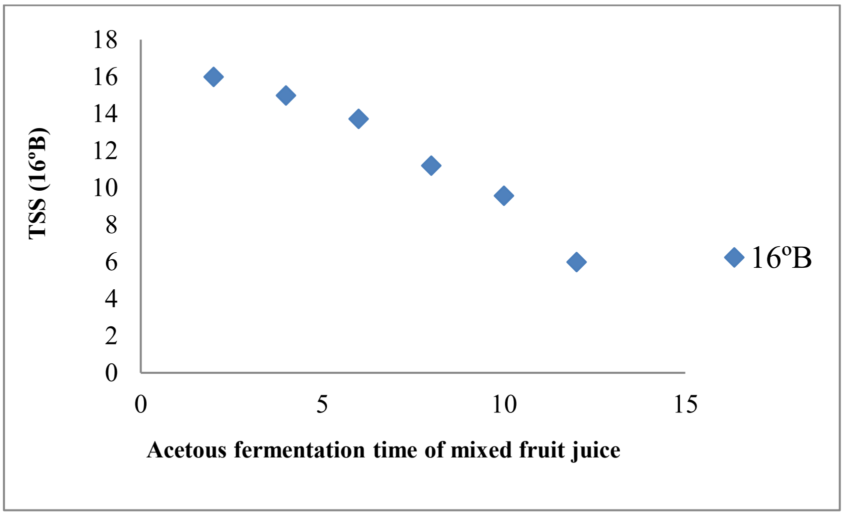

Fig. 5 Changes in level of 16ºBrix in mixed fruit vinegar after acetous fermentation

The temperature also affects the fermentation. The ideal temperature for acetic acid fermentation in the current investigations was 30ºC. According to earlier research by Gullo et al., (2014), raising the temperature causes proteins and nucleic acids to become denaturated, which damages cells. Furthermore, AAB is more sensitive to high temperatures because to the harmful effects of the medium's acetic acid content. The change in acidity during 12 days of acetous fermentation is shown in Fig 6. During 12 days of acetous fermentation, the acidity of mixed fruit vinegar was found to have gradually increased. The acidity of mixed fruit vinegar was increased from 0.16% to 0.84% which was shown in table 5. According to A.S et al. (2021), the steady change in acidity might also be due to the conversion of alcohols to acetic acid, the primary organic acid present in vinegars. Additional organic acids can be generated and are considered to contribute to the vinegar's acidity.

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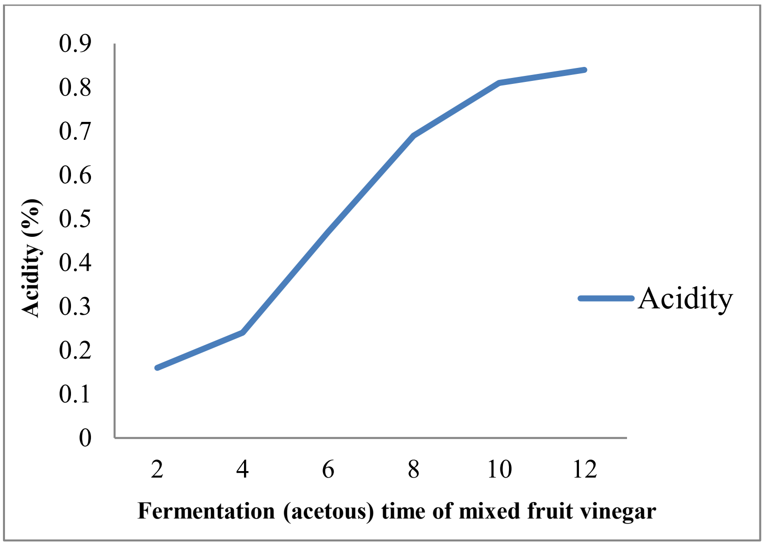

Fig. 6 Change in Acidity during acetous fermentation of mixed fruit vinegar

4.3 Biochemical evaluation of mixed fruit vinegar

The results on Table 6 represents the biochemical characterstics of mixed fruit vinegar include flavonoid, terpenoid, alkaloid, tannin, cardiac glycosides, and mineral contents. Flavonoid content was 2.98 mg QE/mL. A total average of 1.89 mg quercetin/g of flavonoid content was also reported for Shahani DPC (Majzoobi et al., 2020); (Majzoobi et al., 2019). According to Alajil et al. (2021), it ranged from 5 to 15 mg CE/100 g in India, which is in good agreement with our findings. In Italy, Carbone et al., (2018) presented total flavonoid content (TFC) in Apricot cultivars between 1.9 and 12.0 mg CE/100 g. Presence of flavonoid in mixed fruit vinegar play a variety of biological activities, many health-promoting effects, including: Anti-inflammatory properties, Antioxidant properties, Anti-mutagenic properties, and Anti-carcinogenic properties (Panche et al., 2016). Terpenoids were detected by a reddish-brown coloring near the interface. Alkaloids present in low amount i.e. 0.85 mg/mL. According to Amarjeet Kaur and Manoranjan Kalia, (2016) the Bael fruit had 0.42 % tannic acid and 1.03% pericarp. According to the findings published by (Kaushik et al., 2000), the tannin content was 6.6 mg/100 g. Presence of alkaloid in fruit vinegar give the many benefits to human health such as antimicrobial properties (Singh & Garg, 2023), weight loss, antioxidant properties (Afzaal et al., 2022), and help to reduce the metabolic syndrome which can increase the risk of heart disease and type 2 diabetes (Afzaal et al., 2022). Tannin was present at the range of 1.34 mg TAE/mL. A brown ring at the interface indicated the presence of deoxy sugars, characteristic of cardiac glycosides.

Table 6 represents the mineral material values of mixed fruit vinegar. Of the element present in high concentration, potassium was the highest than sodium in mixed fruit vinegar. The high concentration of K reflects the high level of potassium in the raw material used in the production. According to Akarca et al., (2020) the mean mineral material values of Date vinegar were: K; 163.25±0.67 ppm, Na; 31.68±0.08 ppm, Ca; 9.63±0.18 ppm and Mg; 2.58±0.30 ppm, respectively which was close to our study. In addition, Dates can be defined as the richest and most important source of dietary minerals among other common fruits consumed by humans (Mirza et al., 2019). A 100 g portion of Date fruit is enough to provide the 15% of daily recommended. Furthermore, Date fruits contain other minerals, such as iron, calcium, cobalt, copper, magnesium, manganese, phosphorus, and zinc (Baliga et al., 2011). According to Kaur and Kalia, (2017) Bael fruit pulp included the following minerals: P, K, Ca, Mg, Fe, Cu, and Zn. The corresponding values were 51.6, 603, 78, 4.0, 0.55, 0.19, and 0.28 mg per 100g. In the study on the mineral matter content of apple cider vinegar, (Dabija and Hatnean, 2014) found the mineral matter values as Na; 37.69 µg/L, Ca; 32.03 µg/, respectively.

4.4 Organoleptic analysis of mixed fruit vinegar

Table 7 shows the sensory evaluation of mixed fruit vinegar. The organoleptic properties of vinegar are a function of the starting materials and the fermentation method. Acetic acid, the volatile organic acid that identifies the products as vinegar, is responsible for the taste flavor and pungent, lifting odour of vinegar (Umaru et al., 2015). The colour of vinegar scored the highest as can be seen in table 7. This might have happened as a result of the brighter color it provided. Liu et al. (2008), claim that a number of factors influence the color of vinegar, such as the color of the raw ingredients, chemical reactions that occur during production, pigment produced by chemical or enzymatic processes during fermentation, and the addition of caramel colorants. Vinegar is a known for its sour taste. In this analysis, the taste of vinegar was highly appreciable. The raw ingredients utilized, the chemical compound formed during the fermentation process, and the method of fermentation all affect how well-liked the vinegar's flavor and aroma are by consumers (Callejon et al., 2008); (Liang et al., 2016); (Morales et al., 2002); (Ubeda et al., 2012). This indicates that out of all the vinegars assessed, it has the highest level of consumer acceptability. Sossou et al., (2009) reported that all

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volatile organic acid short chains affect the aciditiy, flavor and overall quality of the vinegar. There was no negative rancid flavor of vinegar and this was similar to the work of Kang et al., (2020) in the evaluation of commercial grape vinegars stored for a long time.

Table 1 Physico-morphological properties of fruits-

Sr. No.	Fruits → Parameters ↓	Date	Fig	Bael	Apricot
1	**External color**	Dark brown	Dark red	Green yellow	Red-yellow
2	**Internal color**	Light brown	Dark pink	Light yellow	Orange
3	**Weight (g)**	10-12.6	25-30.6	1114	21-36
4	**Length (cm)**	3.1-6	2.05-3.7	6.2-11	4.49
5	**Pulp Weight (g)**	7-8.24	20.22	67	28.73
6	**Pulp Recovery (%)**	72.9	78.1	55.51	79.1-84.47

Table 2 Chemical characterstics of mixed fruit vinegar-

Sr. No.	Parameters	Mixed fruit vinegar
1.	TSS	6 (ºBX)
2.	pH	4.03
3.	Ascorbic acid	28.37mg/100ml
4.	Acidity	0.84%
5.	Reducing sugar	7.76mg/ml
6.	Total sugar	10.11mg/ml
7.	Total phenol	99.29 mg GAE/mL
8.	Carotenoid	2.83 mg/mL
9.	Antioxidant	53.81%

Table 3 Changes in pH of mixed fruit juice (Date, Apricot, Fig, and Bael) before and after alcoholic fermentation-

Brix (ºBX)	Initial pH	Final pH	Change in pH
14	4.6	4.32	-0.28
16	4.9	4.5	-0.4
18	5.1	4.74	-0.36

Table 4 Rate of fermentation (RF) of fruits must (Date, Apricot, Fig, and Bael) at different Brix (ºBX) after alcoholic fermentation-

Brix (ºBX)	Initial brix (ºBX)	Final brix (ºBX)	Fermentation time (days)	Rate of fermentation (Brix/day)
14	14	10	16	0.25
16	16	9	16	0.43
18	18	13	16	0.31

Table 5 Variations in acidity during acetous fermentation of mixed fruit vinegar-

Sr. No.	Fermentation time (days)	Acidity
1.	2	0.16
2.	4	0.24
3.	6	0.47
4.	8	0.69
5.	10	0.81
6.	12	0.84

Table 6 Biochemical parameters of mixed fruit vinegar-

Sr. No.	Parameters	Vinegar
1.	Flavonoid	2.98 mg QE/mL
2.	Terpenoids	Present
3.	Alkaloid	0.85 mg/mL
4.	Tannin	1.34 mg TAE/mL
5.	Cardiac Glycosides	Positive
6.	**Mineral Content**	

a)	Calcium	11.11 mg/L
b)	Copper	0.65 mg/L
c)	Iron	9.75 mg/L
d)	Magnesium	13.48 mg/L
e)	Manganese	2.61 mg/L
f)	Zinc	3.44 mg/L
g)	Potassium	42.62 mg/L
h)	Sodium	37.71 mg/L

Table 7 General parameters assessed by sensory analysis for the mixed fruit vinegar-

Sr.No.	Parameters	Score
1.	Color	8.41
2.	Aroma	7.75
3.	Taste	7.25
4.	Flavor	8.13
5.	Overall acceptance	8.08

CONCLUSION

From the present investigations it can be concluded that mixed fruit vinegar are a high-quality dietary supplement of minerals, for example K, Ca, and P; phytonutrients and antioxidants such as terpenoids, carotenoids and phenolic compounds. Phenolic compounds have high antioxidant activity, which can help the human body prevent oxidative stress (Shahidi, 1997). Phenolic compounds have been shown to help the body Fight cancer (Soleas et al., 2002) and cardiovascular diseases (Bernatova et al., 2002). This study has explored the value addition of the fruits to produce the nutritious products. Such products can be exploited at household level as well as at commercial level for providing nutritional supplement. Though these fruits (Apricot, Date, Bael, and Fig) are highly perishable and cannot be stored for a longer duration which will ultimately lead to the post harvest losses of such a nutritionally rich fruits and provides a low return to the growers. The value addition can offer a new direction to the farmers who are forced to sell their produce at lower prices and also generate the income and employment to the rural peoples and hence boost the economy of the state. Hence from this mixed fruit vinegar we can get all essential elements and useful compounds of fruits in a single solution. Therefore, based on the current research, it can be concluded that these fruits can also be utilized to make fruit vinegar and make it available to customers as a healthy beverage.

RECOMMEDATIONS & FUTURE DIRECTIONS

- Since the current studies' process was optimized at the lab size, the fermentation must be scaled up to pilot scale in order for companies to accept the technology commercially.
- Research on the physico-chemical alterations that occur with aging can be conducted.
- An Investigation of the Production of Vinegar and Bioethanol.
- Development of a Novel Process for Extracting and Concentrating Organic Acids from Apricot, Fig, Bael and Apricot byproducts for Vinegar Production.

Disclosure statement
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Author Contribution
Amandeep Mor[1*]: Design the study, collect, analyse and interpretate the data, develop methodology, drafting the research paper.

Ikbal Shah[2]: Contribution to the study design, supervision of project.
All authors reviewed and approved the final version of manuscript.
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APPENDICES
Appendix A
Specimen card for sensory evaluation
Hedonic rating test
Name of the panelist: **Date:**
Name of the product: Vinegar
Please test the given sample and check how much you prefer each one. Give points for your degree of perference for each parameter as shown below. An honest expression of your personnel feeling will help me.

Attributes	Sample A	Sample B	Sample C
Color			
Flavor			
Taste			
Aroma			
Overall acceptance			

Description of scale
9=Like extremely 6=like slightly 3=Dislike moderately
8=like very much 5=Neither like nor dislike 2=Dislike very much
7=like moderately 4=Dislike slightly 1=Dislike extremely
Comment if any……………………………………….
Signature……………………………

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