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Research Review

Wine Production from Fruits: A Review

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A B S T R A C T

Fruit wine is an organic fruit preparation made from fermented fruits. Numerous tropical as well as subtropical fruits like kiwi mango, banana, guava, litchi, apple etc. are being utilized for organic wine preparation as they possess suitable taste, delicious flavors, easy availability, apt sugar content and satisfied chemical composition. Recently, manufacturing of fruit wines has been enhanced progressively. With increase in demand of fruit wines there is great potential for development of new fruit products. This often compensates for post-harvest losses that a crop suffers during its peak season. These organic wines are rich in healthy components such as minerals, vitamins and antioxidants that are beneficial for health. The review presents a general outline of the preparation, classification, current status and diverse types of fruit wines.

***Key words*:** Alcoholic beverage, Fermentation, Fruit wine, Must, TSS

Fruits are vital resource of liveliness for humans. They are the chief component of every diet and maintain the health of an individual by providing essential components like vitamins, minerals, carbohydrates, flavanoids, antioxidants and proteins. We get fruits in fresh, dry and processed state. Fruit cultivation as well as production is highest in India. But India also suffers from postharvest losses (up to 45%). The chief reason is inappropriate facilities (low number of food processing units, absence of modern cold storage facilities) and inadequate knowledge as well as handling. The preservation of fruits and vegetables in India is less advanced than the developed countries. Considering all above facts fermentation is an apt approach to preserve fruits and veggies [1].

Fermentation is a feasible method for development of new products possessing customized physicochemical as well as sensory characters. These processed foods have all new flavors and are rich in nutritional components. Widely employed fermentation processes for production of high-quality foods include alcohol, acetic acid and lactic acid fermentations. Among this alcoholic fermentation is extensively used for manufacturing of beverages. Their main component is alcohol and that too ethanol. On basis of taxation and according to regulatory authorities, ethanol beverages are divided into 3 main categories beers, spirits and wines. Beer is produced by fermenting of starch in presence of yeast and contains 4-8% ethanol. For this malted cereal starch such as barley, corn, rye and wheat are commonly used. However, blend of many cereals could also be used. Distillation process is employed for distilled alcoholic beverages such as rum, whisky, vodka etc. that contains 40-60% ethanol. Fruit wines are generally undistilled ethanol drinks (ethyl alcohol 5 to 13%, sugar 2-3%, energy 70-90 kcal/100 mL) frequently prepared from grapes. But sometimes other fruits are also utilized for wine manufacturing. These include peaches, plums, apricots, banana, black current, mango, guava, cocoa etc. Fruit wines are extremely nutritive and possess mild stimulant activity [2].

Various fruit wines have demonstrated to be an exceptional source of vitamins, antioxidants, minerals, and phytonutrients [3]. During its preparation fruits go through two main processes fermentation and ageing. Names of wine are often named after the fruits from which it is prepared [4].

Taxonomy of wine

Cultivation and collection attributes decide the category of wines. Variations in wine are seen due to variation in vinification process, fruit ripening stage, chemical composition of juice, alcohol content, sugar content and ageing of wine. All these factors divide the wine into two chief classes: natural wines and dessert/appetizer wines [5]. Dry wine, are natural organic wines having ethanolic content ranging from 9-14%. Sweet wine, cherries and port wines are categorized under dessert/appetizer wines with ethanolic content of 15-21% [6]. The most renowned wines are red wines, white wines, rose wines and sparkling wines.

A. Red wine It is manufactured from red grapes. It is the most archetypal in the wine kingdom. Various types of aromas are added to red wine such as oak, chocolate, mint, eucalypti etc. The juice made out of black grapes is greenish-white in color. The red color is attributed to the pigment anthocyanin that is abundant in grape peel. Red Italian grapes are collected for procuring Barbera wine. It has low astringency but high acidity along with rounded fruitiness. Cabernet Sauvignon is the most eminent wine. This classy French wine is assortment

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of Cabernet Franc and Merlot. It is loaded with a savor of blackcurrant and bell pepper. Merlot wine is very soft, having amicable flavors. It is a gentle mixture of plum and blackberry flavors. Malbec wine has high content of tannin and is known for its dark red color and. Pinot Noir is made from pinot noir variety of black grapes. Zinfandel red grapes extract gives Zinfandel wine. It has soaring ethanol content, pronounced tannins and is little spicy [7].

B. White Wine White wine has yellow, golden or straw like colour. This depends on whether wine contains skin of grapes or only its juice. It is by manufactured by the anaerobic fermentation of green or gold colored grapes or from selected juice of red grapes. These grapes are cultivated in Europe, Australia, New Zealand, California and Africa. The final product is yellow in appearance. White wines are more refreshing and lighter, when compared to red wines. They are chiefly served during summer season. Chardonnay is a dry white procured from the Chardonnay grape to make champagne. Sauvignon Blanc grape wine is mild but have acidic taste. Sauvignon Blanc grapes are often blended with Sémillon grapes to mellow the intensity. Gewurztraminer has a smooth sweet taste with deep aroma. Muscat wine is procured from Muscat grapes. Pinot Gris grape wine is the most luscious wine, with affluent savors. Sémillon wine is often blended with a Sauvignon Blanc wine for a more rounded and balanced taste. Viognier wine a dry white wine made from superior, rare grapes in the Rhône region of France [8].

C. Pink wine is light pink in color. Peel of grape is detached instantly after the beginning of the fermentation. These wines are made by mixture of "black" and "white" grapes. It includes Dry wines (sugar 0.3% and ethanol 9-14%); Semi-dry wines (sugar up to 0.5-3% and alcohol12.9%); Sweet wines (sugar 3-8% and ethanol 12.9%) [9].

D. Sparkling wine has significant amount of CO_2 for example Champagne. Two levels of fermentation processes are involved in preparing sparkling wine. Bubbles are formed in the wine due to the commencement of secondary fermentation [10].

E. Fortified wine could be red or white wine, which is flavored by the adding together herbs like cardamom, chamomile, cinnamon etc. They serve as a pre-meal appetizer [11].

F. Rose wine is manufactured from red grapes where the juice is allowed to stay in contact with the dark peels of grapes [12].

Wine manufacturing

It involves three major operations, namely pre-fermentation (primary phase), fermentation (secondary phase I) and post fermentation (secondary phase II) [13-15].

A. Pre-fermentation: It involves fruits reception as well as preliminary preparation, which include preparation of musts by crushing, grinding, squeezing, clarifying and finally amending [16]. In the case of grape wines, pre-fermentation involves only crushing the fruit and then releasing its juice. In production of white wine, juice is removed from the peel of the grapes. To decrease the viscosity of white wine sedimentation or centrifugation is employed. However, the peels are not separated from the juice during red wine production.

B. Fermentation: Fermentation is chemical reaction, which converts the sugars of juice into alcohol and CO_2. Yeasts utilize this sugar during the fermentation period. However, sometimes yeasts (fungus) do not utilize the available sugar completely. Therefore, a wedged fermentation leading to decrease or cessation of fermentation occurs. It could be augmented with di-ammonium phosphate $(NH_4)_2HPO_4$ that supply nitrogen, which is required for yeast (*Sacchromyces* sp.) expansion in non-traditional process of winemaking. In white wine production it is first cleared and then yeast is inoculated to commence the fermentation. In red wine whole grape fruit, including pulp, peels and seeds of grapes, is utilized for extracting colour and taste. This process is done after crushing. Yeast is then added to mashed pulp (must). Clarification is achieved by either racking, filtration and/or centrifugation processes.

C. Post fermentation: It is done straight away after the fermentation reaches the preferred stage. Here, wine is racked off the yeast residue, usually in stainless steel vessels or in oak barrels. During storage the wine may/or may not be filtered, cold stabilized & then sieved and/or blended. Numerous fining agents like bentonite, enzymes, diatomaceous, egg albumen, etc. might be incorporated for wines clarification. During maturation wine undergoes various changes at suitable stage. After this wine is strained and bottled.

Fruit wines

Fruit wines are composed of major elements like alcohols, sugars, water, organic acids and minor elements including higher carbon chain alcohols, esters, polyphenols, etc. [17]. For last many decades the classic raw material for winemaking has been the grape. Efforts are being made to produce wines from other fruits also. Their production methodology is similar to that used in production of white and red wines. The main difference present is that it is a little bit complicated to extract the sugar (carbohydrate) as well as some other soluble substances from fruit pulp than it is from grapes. Here specialized equipment's are employed to carefully disintegrate the fruits. Then they are pressed to extract juice from pulp. Another difference is of the sugar content. Juices expressed from some fruits are low in sugar and high in acids than the grape juice. This problem is overcome by diluting the excess acid with water and adding the artificial sugar to correct the sugar deficiency [18].

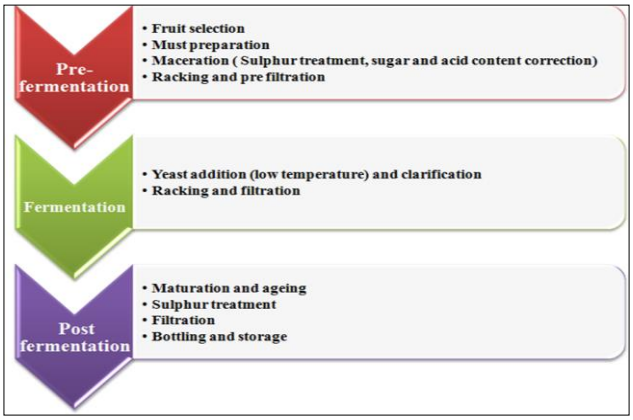

Fig 1 Steps of wine production

While performing fruit wine productions, following points are to be considered carefully:

Quality of fruit: The fruit must have high sugar and low acidic content that should be adjusted if required. In case fruit has low content of natural sugar, it could be incorporated to must to speed up fermentation. If acidic fruits are used (e.g., pineapples raspberries, cherries etc.) for organic fruit wine production it could lead to sour taste of wine. This could be overcome by addition of saccharose (artificial sugar) and water [19].

Preparation of Must: Maceration is the discharge of fruit pomace after crushing that improves must fermentation process [20]. It involves liberation of hydrolytic (digestive) enzymes from crushed fruit cells. Cold pre-fermentative maceration is a shows potential technique, which enhances the pigment extraction, fruit aroma and flavor transfer to the must [21]. For viable maceration, enzyme preparations consist of pectinases chiefly polygalacturonase, pectin lyase and pectinesterase. Very little amount of cellulase and hemicellulase are also used for cell break down and extraction of useful contents [22].

Sulfur dioxide (SO_2) treatment SO_2 is still the main preservatives employed during wine production because it has antioxidant and antimicrobial property [23]. Sulphur dioxide ensures clean fermentation and halts enzymatic browning of the juice [24]. Some phenolic compounds, lysozymes and Dimethyl decarbonate could replace SO_2 according to the requirement.

Fermentation Alcoholic fermentation: The majority of organic fruit wine production is done using *S. cerevisiae* strains because it ensures rapid and reliable fermentation. Furthermore, it reduces the risk of wedged fermentation and microbial contagion [25-26]. Malolactic fermentation Lactic acid bacteria (LAB) also play a very significant role in carrying out a secondary phase I of wine production where L-malic acid is converted to L-lactic acid.

Wine maturation and ageing During wine maturation aroma changes and development of bouquet occurs [27]. Wine ageing has two phases: maturation (for 6months to 3 years) and reductive ageing (in absence of oxygen).

Filtration and bottling Pasteurization is done before wine bottling. By using filtering aids (bentonite, tannin/gelatin) a wine could be cleared [28]. Wines are normally cooled and filtered for improving clarification and stability. Proteins as well as other dissolved substances are removed from the fruit wine before bottling. This prevents haziness, when the wine is heated [29].

A. Mango wine

Mango fruit (*Magnifera indica*) cultivation occupies 55-60% of total agriculture area in India and have 25 cultivars in our country. It is highly rich in amino acids, Vitamin A and Vitamin B_6 [30]. Ripe mango contains disaccharide (sucrose) and monosaccharide (glucose and fructose) as the major carbohydrate source [30], which corresponds to 16-18% w/v. The unripe mango is rich in four carbon containing organic acids e.g., citric acid, oxalic acid etc. On the contrary, in ripe mangoes, malic acid is the main acid. Eating mango exerts numerous [31] health benefits. It is a superior restorative tonic due to high amount of vitamin A and vitamin C. Due to high levels of carotene mango act as anticancer agents [32]. During peak season market is flourished with mangoes and because of inappropriate handling and maintenance more 45% of fruit get destroyed leading to post harvest losses [33]. Therefore, wine production is a good substitute for prevention of fruit loss and utilization of excessive mango into a precious product [34-35]. Previous studies suggested that mango is an appropriate fruit for the making of good-quality white wine [36]. During 19th Century almost 20 cultivars of mangoes were shortlisted from India for making wine [37-38]. The proposed that mango wine possessed similar characters to grape wine. However, vinification technique was not described. Further, ingredients were not mentioned for the manufacturing of mango wine. In year 1987 mango juice was fermented to wine using *Saccharomyces cerevisiae* (yeast) as well as *Schizosaccharomyces* species [39]. Of these *Saccharomyces* species were apt for making dry mango wine having higher alcoholic content. *Schizosaccharomyces* species were appropriate for sweet, table mango wine. In wine preparation initially mango pulp was prepared. Total Soluble Solid (TSS) was then raised (20°Brix) by addition of cane sugar. Sulphur dioxide (100ppm) and pectinase (0.5%) was then put into the pulp. Fermentation was performed using S. cerevisiae (10%) at 22°C for 7-10 days. After that racking and filtration was done. In the end prepared wine is clarified using bentonite and finally bottled with 100 ppm SO_2. They usually have little astringency (low tannin content). Sweet fortified fruit wine of mango known as Dashehari was prepared by adding of 10% (v/v) mango brandy after five days of fermentation [40].

In 2005 mango fruit juice was extracted with ethyl alcohol and pectinase [41]. It was noted that aromatic components of mango fruit wine were equivalent in their concentration to grape wine. In 2009 wine from ten cultivars of mango (Alphonso', 'Raspuri', 'Banganpalli', 'Totapuri', 'Allampur Banesha', 'Neelam', 'Mulgoa', 'Suvarnarekha, 'Rumani' and 'Jahangir' was produced, optimized and characterized [42].

Table 1 Chemical properties of a typical mango wine (*Swami et al*. 2014)

pH	3.70 (Acidic)
Ash	0.27 %
Extracted Wine	0.41%
Total Soluble solids	5.0°Brix
Specific gravity 30°C	0.98
Ethanol	13.82% (v/v)

Banganpalli', 'Totapuri' and 'Alphonso' cultivars are found to be the most apt for mango wine making, on the basis of their physico-chemical properties as well as sensory characteristics. A wine from Apple mango mixture was also made by varying both temperature (20°C, 25°C, 30°C and 35°C) and the S.cervisiae concentration (0.0065%, 0.01%, 0.05% and 0.1%). It was noted that rise in temperature increased the fermentation kinetics remarkably [43]. But at elevated temperature (35°C) and *S. cervisiae* concentration of 0.1%, sugars were not entirely used during fermentation and ethanol yield was lowest (6.93%). At 25°C the ethanol amount was highest (9.44%). Yeast concentration (*S. cerevisae*) of 0.05% at 25°C provided the most favorable characteristics for Apple mango fruit wine.

B. Banana wine

Just like mango, banana (*Musa peradisiaca*) is a tropical fruit that is cultivated lavishly in India. They contain high nutrition content of carbohydrates, potassium and vitamins such as B_1, B_2, B_3, B_{12}, C and E. Bananas can be dried and converted into flour, chips, and dried fruit [44]. Traditional banana fruit juice extraction and its fermentation to produce beer (tonto) is vital communal and fiscal activity among loads of tribes of East Africa [45]. For beer preparation poached bananas are minced [46]. The fabrication of banana wines avoids the post-harvest losses. Consumption of banana wine diminishes anemia, depression, stress, hypertension, stroke, heartburns and digestive disorders like constipation. It bestows fortification for bones, eyesight, nerve functions and kidney malfunctions [47].

Preparation of banana fruit wine: For preparation of organic banana wine traditionally, the banana fruits were cooked, juice was then extracted and blended with S. cerevisiae, citric acid, maize flour and sugar. It was then left for complete 2 days in the pot. Then it was positioned into a can and air locked for 14-30 days. It was then filtered with aid of siphon into a different can. It was reserved for short period before consuming. In 1976, another method was developed for banana fruit wine production that includes its manufacturing from banana juice as well as pulp (through 1:0, 1:1 and 1:2 dilution) [48]. They noted that increase in dilution leads to decline in concentration of alcohol and phenol in wine. However, increase in dilution leads to rise in sugar content. Then clear juice is obtained by centrifugation, for making wine [49]. Various experiments were performed to optimize banana fruit juice extraction via alteration in incubation periods and amount of petinase [50]. Based on these findings 0.2% pectinase and 4 hours incubation period were finalized for juice preparation. Bananas were pared and blended to obtain a pulp. $K_2S_2O_5$ (100 ppm) was included to avoid browning as well microbial contagion. Fermentation was performed at18±10°C. Thus, classic wine is procured from over-ripe banana fruit, whose characters are discussed in (Table 2) [51].

Table 2 Chemical composition of a banana wine (*Akingbala et al*. 1992)

pH	3.85
Ash	0.27g/100g
Extract	0.43g/100g
Soluble solids	5.2 °Brix
Specific gravity 30°C	0.98
TA	0.33%
Ethanol	14% (v/v) aprox

In 2003 researchers discovered a significant decrease in total soluble solids (TSS) and rise in acidity with increasing time period of juice fermentation [52]. Juice was refined to 180°Brix and the wine formed exhibited 4.8°Brix TSS and 0.85% titratable acidity after a period 14 days. [53] postulated that total soluble solids of must of Poovan reached 8.0°Brix, Robusta reached 6.9°Brix and Rasthali reached 5.4°Brix from 23°Brix, throughout twenty-eight days of process of fermentation. But must made from juice of Poovan, Robusta and Rasthali cultivars exhibited reduction of TSS up to 6.5, 4.5 and 3.9 °Brix, respectively. It was noted that during initial week fermentation proceeds very rapidly. Further, there was no alteration in total soluble solids of wine made from banana (Robusta juice and pulp). It is stored for a period of 90 days at room temperature of 28±2°C and refrigerated temperatures of 5°C. In another technique Banana pulp was prepared and then treated with pectinase (0.25%) for 45 min. Banana juice was obtained in which sugar was adjusted up to 22°Brix and pH was maintained at 4. Di-ammonium phosphate was then added along with SO_2. Inoculation was done with S. cerevisiae (NCIM 3283 and NCIM 3046). It was left for 9 days at temperature of 260°C for fermentation. Racking and bottling of prepared wine was then done. Finally, wine was pasteurized for 3 min at 600°C and 0.1% bentonite was added [54].

Table 3 Ethanol and pH content of some important fruit wines

Fruits wine	Ethanol (%)	pH
Mango	7.4	4.1
Banana	5.49	3.3
Grape	9.4	3.7
Papaya	8.73	3.3
Litchi	11.4	3.05
Orange	8.65	3.1
Lime	0.93	3

C. Apple cider/wine

Placid ethanolic beverages are produced from Malus domestica (apple) [55]. The apple is mainly coupled with cider [56]. Cider is in fact a low alcoholic drink made by fermenting the apple juice. Cider could be sweet (having no CO_2) or dry (little sugar and ethanol 6-7%) [57] and according to ethanol content, cider could be soft (1-5%) or hard (6-7%) [58]. Cider fermentation occurs at 15-18°C. SO_2 is added for clarification and to control microbial contagion [59-60]. It also controls the growth of micro-organisms in the must and produces a cider of consistent quality [61]. Concurrent fermentation with *S. pombe* and *S. cerevisiae* prepared cider possesses tolerable alcohol as well as acidity level [62]. Stainless steel tanks are commonly used for fermentation of cider. Bulk storage of ciders is done at 40°C. After completion of fermentation process, the final product is racked and filtered. When it is left for aging, the suspended material settles at the bottom leaving the clear liquid that could be further clarified using bentonite, gelatin or casein, and then finally filtered. It could be either pasteurized at high temperature of 600°C for 20-30 min or SO_2 can be added which serves the same purpose [63]. Apple wine is one more product prepared by apple juice using alcoholic fermentation and possesses ethanol levels of 11-14% (more than cider). Apple pulp is the fundamental raw material and amelioration is done using sugar and/or juice concentrate [64]. For decreasing the higher alcohol output in wine, $NH4^+$ is added to fermenting solution [65]. It is advised to wash and crush the fruits, add SO_2 (50 ppm) and 10% water for making apple wine. Adding diammonium hydrogen phosphate progresses the ferment ability [66].

D. Guava wine

Guava juice is extracted and treated with pectinase (0.05mg/100ml) at temperature of 45C, for 6hrs. 95 v/v of *S. cervisiae* strain 35 and 0.35 DAPH w/v was added. Ethanolic fermentation occurs. Decantation and storage are then done [67].

E. Citrus wine

Orange and Lime is taken and completely peeled off. The pulp is then macerated and pasteurized at 85°C-90°C for 5 minutes. Ethanolic fermentation occurs. Decantation and storage are then done [68].

F. Papaya wine

Papaya is taken and was completely peeled off. The pulp is macerated in mixer/blender and pasteurized at 85°C-90°C to 5 minutes. Alcoholic fermentation occurs. Decantation and storage are then done [69].

G. Litchi wine

Litchi fruits are peeled off. Pulp obtained is then crushed for juice extraction. The must prepared is filtered (17°Brix) and subsequently treated with sodium metabisulphite (100 µg/ml). The pH of the juice is maintained at 3.8. It is then inoculated with 2% (v/v) *S. cerevisiae* var. Bayanus [70]. Fermentation is performed at 30±2°C for 6 days. Once TSS reached 4-6°Brix, wine racking is done. 2 to 3 more rackings are performed at interval of 15 for removal of unwanted sediment. 0.04% bentonite is added for wine clarification. Sodium metabisulphite (preservative) is again incorporated before bottling [71].

H. Indian gooseberry / Amla Fruit wine

Amla wine possesses medicinal properties of amla fruits. *S. cerevisiae* was selected for fermentation, which was performed at 30°C with 20% initial sugar concentration and at pH of 6. Superior fermentation efficiency was observed due to increase ethanol production 8.9% (v/v) [72].

CONCLUSION

Wines are probably the most antique fermented brew and were revealed in the Bible and in other historical documents from Asian countries. Organic fruit wines are actually a food having fruit flavors. They contain nutrients equivalent to original fruits as they are undistilled. They possess many health aids such as anti-ageing, lung function improvement, reduction in cardiovascular disease and reduction in ulcer-causing bacteria. These are portable and one can stock up them easily. Moreover, their nutritive value is further augmented by yeast (*Sacchromyces* sp.) during fermentation. It liberates amino acids and a mixture of nutrients. The earlier phase has seen the brisk expansion of fruit wine industrialization globally. Moreover, customers' requirement for luxury fruit wines is rising and consequently is the marketplace. So, developing technology for manufacturing of organic fruit wines in India can originate to be of great benefit.

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