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Role of Mango in the Production of Wine: A Review

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Abstract: Mango is considered to be one of the most cultivated tropical fruits around the world. India is one of the largest producers of mango, accounting for an estimated 45% of the total world mango fruit production. India exported 27,872 metric tons of mango, worth 327.45 crores in 2020-21. Mango is a perishable fruit with a very short shelf life, which leads to wastage. To minimize or utilize the wastage, alternative mango-based products are being produced. Mango wine is one of the alternatives for surplus mango production. It is cost-effective and helps minimize post-harvest losses. The Philippines is the largest manufacturer of mango-based alcoholic beverages, such as mango wine and rum. Locally, mango wine is a popular home-based alcoholic beverage in the Philippines. India and Kenya are also experiencing significant growth in fruit wine production. The available literature on the production and characterization of mango wine briefly describes the fermentation and characterization procedures followed. The physiochemical properties and volatile composition of mango wine, including ethanol, esters, total soluble solids, and sensory analysis, are also highlighted in the review. The study provides evidence that the antioxidants and immunoboosters can reduce the risk of chronic infections.

Keywords: *Mango wine, fermentation, fruit wine, physiochemical analysis, mango pulp*

1. Introduction

In tropical and subtropical regions, the mango (*Mangifera indica L.*) is a beloved fruit. Its exceptional aroma, enticing fragrance, exquisite taste, and high nutritional value have distinguished it as one of the finest fruits. One of the most important and commonly cultivated fruits in the tropics is the mango (*Mangifera indica*), a member of the cashew family (*Anacardiaceae*). There exist several varieties of mango trees, which are believed to originate from southern Asia, particularly Myanmar and the Indian state of Assam. Mangoes are rich in Vitamins A, C, and D. India holds the position of the leading mango producer globally, contributing nearly 50% of the total production. Other significant mango-producing countries include China, Thailand, Mexico, Pakistan, the Philippines, Indonesia, Brazil, Nigeria, and Egypt. India alone accounts for 12 million tons, representing approximately 52% of the global output of 23 million tons. Global mango production, averaging 22 million metric tons per year, has been increasing. Asia dominates 75% of the production, followed by South and North America, which have around 10% each. Uttar Pradesh (23.86%), Andhra Pradesh (22.14%), Karnataka (11.71%), Bihar (8.79%), Gujarat (6.00%), and Tamil Nadu (5.09%) are the leading mango-producing states in India. India exports mangoes to over 40 countries, with the UAE (61.79%), Bangladesh (11.41%), the United Kingdom (8.92%), Saudi Arabia (3.79%), Kuwait (2.32%), and Bahrain (2.19%) being the top importers of Indian mangoes (National Horticulture Board).

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Alphonso: The Portuguese commander Afonso de Albuquerque inspired the name of the Alphonso mango, sometimes referred to as the King of Mangoes. Due to its unparalleled flavor and texture, Alphonso is the most sought-after mango cultivar globally. Grown in the Konkan region of Maharashtra, Alphonso is credited with establishing the mango as India's national fruit. The Konkan region's Alphonso mango has been granted the Geographical Indication designation.

Langra: Varanasi is a renowned destination for mango enthusiasts in India, known for its Langra variety of mangoes. The tale of a farmer who nurtured this particular type of mango is well-known among locals. The Banarasi Langra mango, available between June and July, is famous for its flavor and lemon-yellow skin. Dasheri, Himsagar, Kishan Bhog, and Chausa are other varieties of mangoes cultivated in India. (Detailed project report mango ready to serve manufacturing unit – IIFPT, Tanjavur)

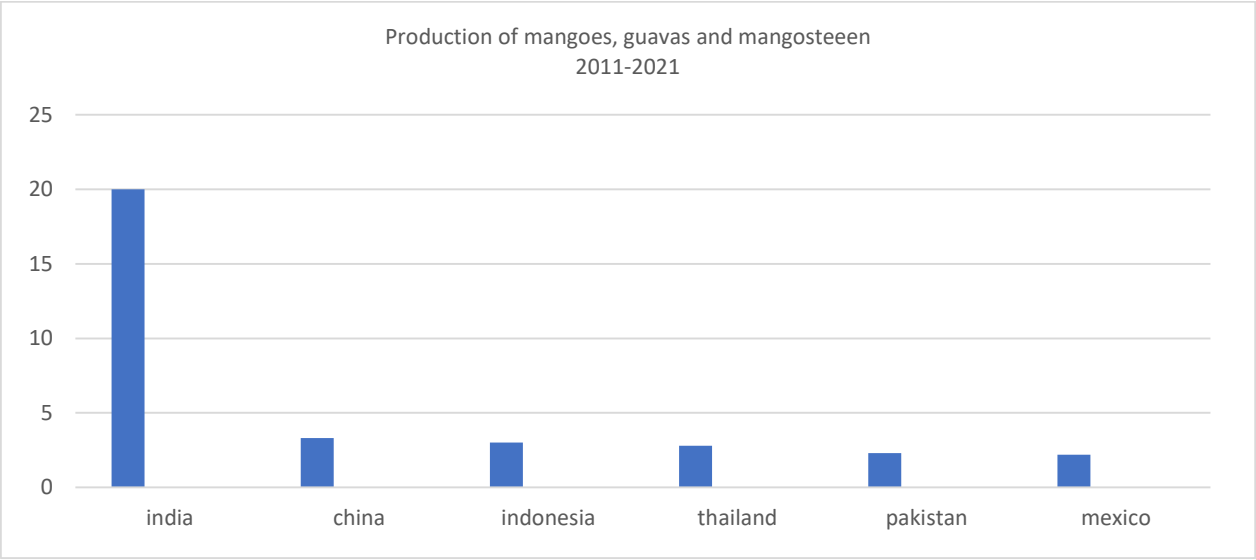

Figure 1. Graphical representation of production of mangoes, guavas and mangosteens in 2001-2021. (Source: Food and agriculture organization report 2021)

2. Reason for Mango Wine Production

Despite grapes being the primary raw material used to make wine, there is a growing interest in finding other fruits, such as apricot, apple, and palm sap, that are ideal for making wine. Local fruits that are inexpensive and easily accessible are utilized as an alternative to grapes in nations where they are not widely available. In developing nations like India, there is a 20–30% loss in fruit production due to post-harvest issues, improper use, along with processing technology. Converting garbage into value-added goods like wine is a clever solution to this issue. The production of mango wine is in high demand worldwide for several reasons, some of which are listed below. Mangoes are abundantly available throughout the season due to advanced technologies in the agriculture sector. This leads to an increase in fruit waste production. Fruit waste accumulates due to deteriorated, unsightly fruit skin colors, and improper storage temperatures. One of the most cost-effective ways to reduce fruit waste, in this case, is the production of wine from mango fruit. Figure 2 illustrates the increased revenue brought in by using mangoes in wine production, generating around 5,500 USD for 1 tonne of mangoes. This clearly demonstrates that producing wine is an efficient way to utilize surplus mango fruit.

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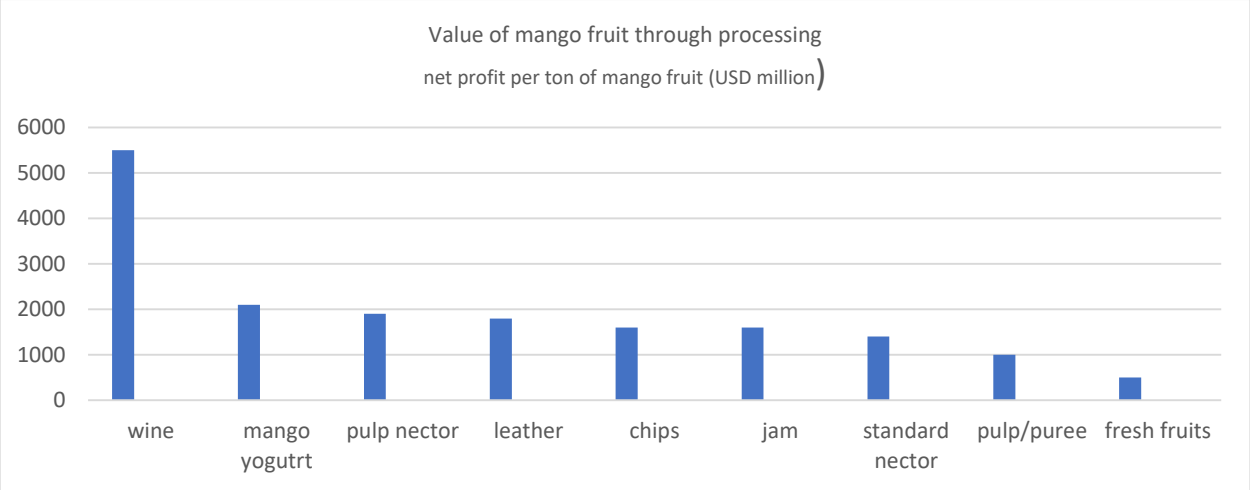

Figure 2. Net profits derived from processing one ton of mango (Source: FAO 2021 report)

3. Statistical Data of Mango Wine Production

France, Italy, and Australia have established themselves as leaders in the wine industry, thanks to their abundant grape production. India is ready to invest in its surplus mango production and transform it into value-added products. One option to maintain the flavor of mango fruit throughout the year is to create mango-based beverages, which will ultimately mitigate post-harvest losses during processing operations.

Figure 3. Representation of Indian wine export in 2002-2014 (Source: www.enterpreneurindia.co)

Despite the lack of statistical data on mango wine, this article aims to provide relevant information about mango wine production. According to available data, the Philippines is a major producer of mango-based alcoholic beverages such as mango wine, mango rum, and whisky. Mango wine is a popular home-brewed alcoholic beverage in the Philippines. However, the majority of beverages produced are for personal consumption. "Filipinos are manufacturing different types of wine and liquor that are set to take the global market," stated Ambassador Jose Maria Cariño, who heads the DFA's Cultural Diplomacy Unit. Developing nations such as India, Kenya, and Mexico are showing significant growth in fruit wine production. Mango wine is being developed by a group of mango growers in Andhra Pradesh. Five hundred farmers have registered and are collaborating to create value-added mango products. In addition, another 4,000 farmers are working to bring quality fruits, select, and process fruit concentrates and pulp for various mango delicacies.

4. Statistical Data of Mango Pulp

Mangoes are grown in India. In practically every region of the nation, there are numerous types to be found. Certain types of fresh mango fruit are used to make mango pulp. The completely developed mangoes are picked, swiftly transferred to the facility that processes the fruit, where they are examined and cleaned. Controlled ripening chambers are used to thoroughly ripen selected, high-quality fruits. Following thorough cleaning, the fruits are blanched, pulped, deseeded, centrifuged, homogenized, and concentrated as necessary. They are thermally processed and aseptically filled to maintain sterility. Mango pulp is a prominent export from India. During the years 2021–2022, the country exported 123,476.69 MT of mango pulp to the world for a total of Rs. 924.52 crores/124.11 USD Million. Half of the estimated 700,000 tonnes of mango pulp production worldwide come from India, which yearly produces 350,000 tonnes. India uses 150,000 tonnes of pulp domestically and exports 200,000 tonnes (APEDA). Major export destinations are Saudi Arabia, Yemen Republic, USA, Netherlands, UK, and Germany. Mango puree, also known as mango pulp, is a smooth and thick product that is processed to break up the fibrous, insoluble components of ripe mangoes. It retains all of the fruit juice as well as a significant amount of the naturally occurring fibrous material present in raw fruit. Mango puree is occasionally pasteurized to lengthen its shelf life.

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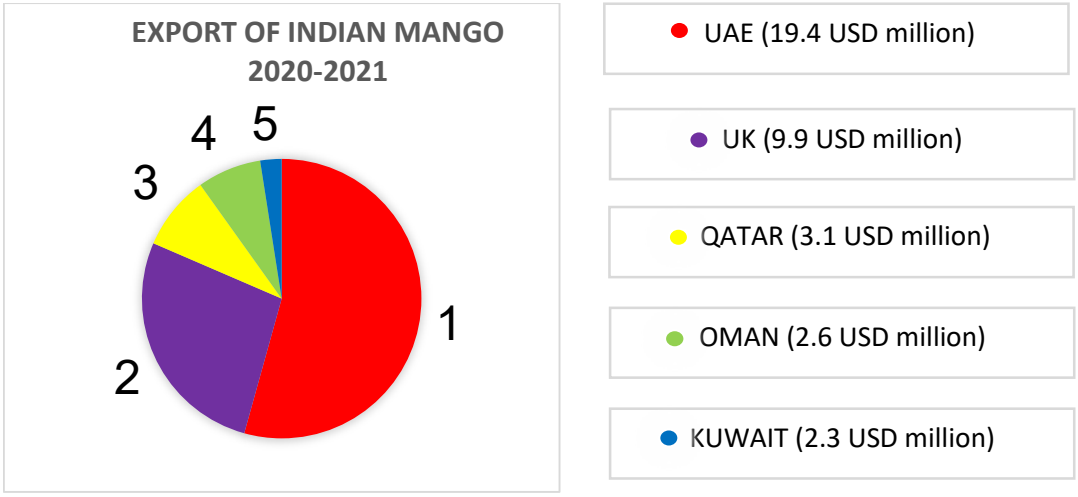

Figure 4. Export of Indian mangoes to different countries (Source. FAO report 2021)

The Middle East leads the market in both consumption and imports, with over 20% of all imports coming from the European Union. The fruit juice sector in Europe is the biggest consumer of mango puree, but it is also used in other industries, including ice cream and infant food. Mango pulp sales experienced exponential growth, and this trend is anticipated to continue. With a widely recognized variety of mangoes, mainly from India, being the leader among major mango farmers. Alphonso, Totapuri, and Kesar are employed in the pulp-making process. Mango pulp is a major food ingredient used in making mango-based beverages like mango juice and Mango wine.

5. Selection of Variety of Mango

Selection of mango variety depends on the percentage of mango juice yield and its quality, as well as its physicochemical characteristics. The availability of total soluble sugars (TSS) determines the amount of ethanol produced during fermentation. Furthermore, mangoes rich in glucose and fructose are readily available for yeast to convert into ethanol and carbon dioxide. Varieties like Alphanso, Banganpalli, and Totapuri are widely used in India for mango wine production, while Haden, Kent, Keitt, Ataulfo, and Tommy Atkins varieties are common choices in Mexico and Kenya. Previous studies have also utilized different types of South Indian mango varieties including Banganpalli, Alphonso, Raspuri, Totapuri, Banesha, Neelam, Mulgoa, Suvarnarekha, Rumani, and Jahangir (Reddy and Reddy, 2005). Among these, only a few varieties are suitable for winemaking. However, the present study aims to investigate the local mango varieties in Varanasi, Uttar Pradesh. Vikash Patel and Abhishek Dutt Tripathi (2020) screened five types of mango varieties, namely Banganpalli, Dashehari, Alphonso, Langra, and Totapuri. Among these, Banganpalli exhibited the highest mango juice yield, followed by Totapuri and Dashehari.

6. Selection of Yeast Strain

Sugar fermentation in wine is carried out by yeast cells in the inoculum. The primary factor separating wine from fruit juice is the function of yeast in the winemaking process. The potential alcohol content of the wine increases with the amount of sugars in the juice yield. Saccharomyces cerevisiae is the most prevalent yeast used in the production of wine. Different yeast strains were employed by various researchers. Each strain develops its distinct flavors during fermentation and has its own enzymatic patchwork. In this current study, Vikash Patel and Abhishek Dutt Tripathi (2020) used the freeze-dried Saccharomyces cerevisiae MTCC 178 strain collected from the Indian Institute of Microbial Technology, Chandigarh (India). The Department of Plant Pathology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, provided another yeast isolate (ISY). These yeast strains were initially revived with peptone water and seeded onto PDA, which will be further used as inoculum preparation. Three Saccharomyces strains were employed by Reddy and Reddy in 2005. CFTRI 101 produced the most promising results during fermentation, followed by the other yeast strains isolated from palm wine and baker's yeast (Aman, 2022; Sing, 2021).

7. Fermentation

A complex substrate is turned into simple chemicals by the biological process of fermentation, which involves a variety of microorganisms including yeast, bacteria, and fungus (Ritika Joshi, Vinay Sharma, and Arindam Kuila*). Numerous investigations have revealed various fermentation methods utilized in the production of mango wine. The fermentation method differs in the use of various factors such as time, temperature, pH, and the type of yeast strain being implemented. However, Vikash Patel, Abhishek Dutt Tripathi (2020) used the batch fermentation technique carried out at 20°C for 15 days. Reddy and Reddy (2005) maintained the pH values at 3.5, 4, 5, and 6 and the temperatures at 20, 25, and 35°C for a period of 20 days.

8. Physicochemical Analysis of Mango Pulp

Physicochemical characteristics of mango juice include estimations of its total soluble solids, pH, and final titrable acidity. Through the use of a refractometer, brix readings were estimated. With the help of a pH meter and the DNS approach, the pH and reducing sugars were determined.

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Table 1. Physiochemical properties of different mango varieties

Tests	Alphonso	Banganpalli	Alphonso	Banganpalli
TSS	18.60 ± 1.27	16.72 ± 1.28	16.0	20.5
Reducing Sugars	16.60 ± 0.80	2.1 ± 0.10	16.3	18.5
TA	0.44 ± 0.01	0.34 ± 0.06	0.350	0.326
PH	3.7 ± 0.80	4.2 ± 0.85	4.1	4.0

Source: (Vikash Patel & Abhishek Dutt Tripathi, 2020; Reddy & Reddy, 2005)

Volume of juice yield plays a crucial role in wine production, as it represents the ultimate amount of liquid obtained from fruits. Fruits with a high juice yield are preferred for wine making. According to estimates by Vikash Patel and Abhishek Dutt Tripathi (2020), Banganapalli and Totapuri varieties had the highest juice yield, with 16.72 and 13.26 TSS (Total Soluble Solids) respectively, whereas Alphanso and Langra had the lowest, with TSS of 18.60 and 15.57 respectively. Reddy and Reddy (2005) found that Banginapalli, with 20.5% TSS, was ideal for mango wine production. Li et al. (2012) conducted a study on three mango varieties (R2E2, Harum Manis) and concluded that Nam Doc Mai was the superior choice. These two studies showed slight variations in their findings.

9. Physicochemical Analysis of Mango Wine

According to research conducted by Vikash Patel and Abhishek Dutt Tripathi, the maximum ethanol concentration of the Banganapalli and Dashehari wines in the MTCC 178 (S2) yeast strain was 13% and 12% (v/v), respectively. The ethanol produced by the ISY (S1) sample also has close proximity with the ethanol produced by the MTCC 178 (S2) sample in Banganpalli and Dashehari varieties (13% and 11.5%). An earlier study by Reddy and Reddy (2005) revealed that using the CFTRI 101 yeast strain, the Banganapalli variety of mango produced 14.2% ethanol. The Langra (13.8) and Totapuri (11.8) varieties had high TSS, followed by Alphonso (11.0) with the S1 yeast strain. In both studies by Vikash Patel and Abhishek Dutt Tripathi (2020) and Reddy and Reddy (2005), the TA% value of the wine made from Alphonso was 0.600. The HPLC study of Dashehari and Langra wines also revealed the presence of gallic acid (3,4,5-trihydroxy-benzoic acid), a phytochemical with strong antioxidant qualities. The P-Hydroxybenzoic acid shows antioxidant, antibacterial, and antifungal properties (Vikash Patel, Abhishek Dutt Tripathi, 2020).

10. Factors Effecting Mango Wine Production

Alcoholic fermentation results from complex interactions involving the quantity of sugars present, yeast strain, and combinations of time and temperature. The ultimate quality of wine is significantly influenced by these factors. Numerous investigations have identified the elements that are evident during the fermentation process.

pH

The most significant controlling factor in the fermentation process is usually considered to be pH. Due to the activity of yeast during fermentation, the pH of wine is likely to increase. The ideal pH is proven to be crucial for the production of high-quality wines. So far, the Totapuri Variety Mango wine contains a high pH of 3.0, whereas the Langra variety of mango wine has a low pH of 4.0 (Vikash Patel and Abhishek Dutt Tripathi, 2020). Kumar et al. (2009) determined that a pH of 3.8 was suitable for mango wine fermentation.

Temperature

The fermentation process in winemaking largely depends on temperature. The ideal temperature for good quality wine is 68-86°F (20-30°C) (Reynolds et al., 2001). Wines that are fermented at low temperatures, such as 15°C, are lighter and more fragrant. When the proliferation of yeast cells doubles or declines, the temperature may rise or fall. Maintaining a constant temperature throughout the secondary fermentation is another efficient method for enhancing the quality of the final wine. Mango wine may be most effectively made around 25 °C.

Time

Since they have an effect on the end product's quality and content, fermentation time and temperature are essential (Mpho Maleke & Wesley Doorsamy, 2022). All varieties of Banganpalli, Totapuri, Langra, Mashehari, and Alphonso give better wine quality at a temperature of 25°C for 15 days (Vikash Patel and Abhishek Dutt Tripathi, 2020).

11. Medicinal Benefits of Mango Wine

Mangoes are claimed to be an excellent source of various vitamins, such as A, B, and C. Moreover, minerals like calcium, magnesium, iron, sodium, and phosphorous are found in mangoes along with vitamins. Additionally, malic, citric, and tartaric acids are present in small amounts in mangoes (Fizza Mubarik et al., 2020; Khongthaw et al., 2022; Dulta et al., 2021). Among multiple cultivars, the most common carotenoid is β-carotene, which is essential as a lipophilic radical scavenger. The total carotenoid content in mango wines ranges from 578-4330 g/100g, with Alphonso having the highest quantity at 4330 g/100g, followed by Sindhura at 4101 g/100g, Banginapalli at 2943 g/100g, Rumani at 2857 g/100g, and Totapuri at 690 g/100g (Reddy and Reddy, 2005). Ascorbic acid is another compound that increases during mango wine fermentation, effectively scavenging reactive oxygen and nitrogen species, including superoxide and hydroperoxyl radicals (Carol S. Johnston et al.,

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2013). Reddy and Reddy's study on Alphonso mangoes revealed eleven distinct phenolic compounds. The Totapuri mango variety exhibited the highest content (1050 mg/l), followed by Alphonso, Banginapalli (725 mg/l), Sindhura (725 mg/l), and Sindhoora (490 mg/l), respectively. These polyphenols possess anti-inflammatory and antioxidant properties that could have advantageous preventive and/or therapeutic effects against obesity, cancer, neurological diseases, and cardiovascular ailments (Hannah Cory, Simone Passarelli, and Josiemer Mattei, 2018). In the research by Vikash Patel and Abhishek Dutt Tripathi, the Dashehari mango wine treated with S1 included gallic acid, a phytochemical with exceptional antioxidant properties that could serve as a potential functional food ingredient. The study also indicated that S1-treated Dashehari and Langra varieties of mango wine contained a significant amount of flavonoids and polyphenolic compounds.

12. Cost Economics

According to the study, 1305 ml of mango juice is required to make 1 L of wine. For 1L of wine, 2.25 kg of mangoes are required. The cost of raw materials is around Rs. 100, based on market prices. Therefore, the study provided evidence that 1L of mango wine will cost about Rs. 250. However, the Reddy and Reddy 2005 study showed a significant difference in the capital cost. There is only Rs. 100 cost for producing 1L of mango wine. The variation in the cost of 1L of mango wine in both studies is due to the cost of raw materials (mangoes) used and processing steps. The scale-up will, however, take the actual cost of production into account.

13. Other Fermented Products from Mango

Mango Feron

Mango Feron is the process of making ethanol from mango leaves. The students from Jiwaji University made an attempt to make wine from mango leaves and named it Mango Feron. The study reports that mango feron is rich in antibacterial properties and has shown significant results in the treatment of diabetes. The base wine contains approximately 8–12% ethanol.

Mango Vermouth

Mango vermouth is an aromatic fortified wine created from mango juice. Vermouth is described as a fortified wine with spices, aromatic compounds, and added flavors. Vermouth is another term for an aperitif.

Cashew Apple Wine

It is also one of the emerging alcoholic beverages in the brewery industry. It is usually made from the leftover part of the cashew fruit or false fruit. It is an effective method to utilize the waste generated from the cashew manufacturing industry.

14. Conclusion

One of the tropical fruits that are most widely grown worldwide is the mango. It is abundant in sugars and other crucial nutrients needed by humans. One of the beverage markets that is expanding the quickest globally is the fruit wine sector. By creating alternative fruit-based products like fruit wine, jams, and jellies as well as incorporating them into other foods, developed countries are able to utilize their excess fruit production. However, because of a lack of technology resources, developing countries fail to make the most of their fruit supply, resulting in a 5–10% fruit loss rate. This study focused on using the mango fruit to produce wine (*Mangifera indica*). This article provides a quick overview of the ethanol production process using local mango varieties such as Alphonso, Totapuri, Langra, and Dashehari. Mango wine consumption has many health advantages in contrast to its low alcohol content. The goal of this research is to promote fruit wine's potential health benefits while also accelerating the market for the beverage.

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