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Tropical fruit wines: A mini review

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ABSTRACT

This paper reviews the wine produced from different tropical fruit sources that is gradually gaining a market potential. The tropical climate is suitable for some of the world's most exotic and delicious tropical fruits. The tropics are generally defined as the regions of the globe between the Tropic of Cancer and Tropic of Capricorn where environmental conditions are unique, creating a habitat for incredible diverse crops and plants. Edible tropical fruits such as jackfruit, cashew apple, mangoes, papaya, pineapple, litchi, guava, bael, banana, pomegranate, tendu, jamun and palm etc. with high export potential have their origin in the tropics and require rather a tropical or subtropical climate; and do not tolerate frost. Most of the tropical fruits are important sources of antioxidants, vitamins and minerals and form a very healthy part of a diet. An effective utilisation of inferior grade and over-ripe fruits and processing them into fermented beverages has been revealed as a new and promising alternative to generate extra revenues whilst conducting a sustainable exploitation of wastes. Concerning this, the manufacture of wine from fruits other than grapes has been boosted in recent years.

KEYWORDS

Tropical fruit;
Wine;
Antioxidant.

INTRODUCTION

Tropical countries possess a wide diversity of fruits with many possibilities of commercial exploitation; some of them are considered rare and exotic. Wine is one of the most recognizable high value-added products from fruits. Wine manufacturing has always been challenging, in the sense of obtaining a marketable product, but the processes involved in its production are relatively straightforward[1,2]. Acceptability of wines can be made from practically all fruits. There are some soft fruits from both temperate and tropical regions whose pigment stability and flavour profiles match those of wine from grapes, but suffer from the lack of intensive research and development in the way to commercial production. As an alternative to full-strength wine, wines with a reduced alcohol content offer a number of potential social and health benefits for consumers and have been commercially available for over two decades. It's already evident with numerous studies that have been carried out in the health and wine field that supplementing the regular diet with wine increases the total antioxidant capacity in plasma, reduces oxidative damage and platelet aggregation. Studies from different parts of the world with diverse population groups, suggested that moderate consumption (1–2 glasses per day) of wine drinks reduce cardiovascular risk[3-5]. This review will assist wine makers in evaluating the relative merits and limitations of the current tropical fruit wines available and open up scope of research for new ones for effec-

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tively producing quality tropical fruit wines and having acceptance of these wines.

CLASSIFICATION OF SOME TROPICAL FRUITS

Tropical Fruits can be classified in various ways. Classification is mainly based on acidity, bearing, size, and seed type. The classification based on acidity comprises four sets of fruits: alkaline, sub acidic, acid, and melons[6]. Alkaline fruits have a characterizing sweet taste and high sugar content while acid fruits have sour taste and high concentration of citric, malic and oxalic acids. Sub acidic fruits have a taste somewhat between sweet and sour. Melons have a distinct feature of sweet taste with high moisture content. Fruit-bearing plants are also categorized in several ways. Among the tree fruits are the citrus fruits while vine fruits are grapes and kiwi. Berries are classified as bush fruits. Herbaceous fruits have minimal or no woody tissue. Tender, nut, pome, and stone fruits are another way of classification (Figure 1). Tender fruits comprises of pineapple, pomegranate and jackfruit etc. Nuts such as pequi and pitomba have a hard outer shell surrounding an inner edible tissue that is consumable. Pome fruits bears a fleshy fruit surrounding a central core of seeds and mainly consists of apple, acerola, peach, papaya, guava, melon, sapota and pinha etc.. Stone fruit bears a single pit in the centre, they are commonly referred as stony fruits.(avocado, cherry, jambo)[6].

TROPICAL FRUIT WINES

Fruit wines are prepared from a variety of fruit sources whereas tropical fruit wines are mainly prepared from fruits including berries which are predominant in the tropical and sub-tropical regions. Some of the notable tropical fruit wines that has gained some amount of popularity indigenously are mango[7], banana and pineapple[8], litchi[9]. Tropical fruit wines are mainly developed for a distinct economical purpose. The maturity and harvest of large quantities of ripe fruits rapidly deteriorate and are usually wasted as a result of poor handling and inadequate storage facilities. For this concern it becomes essential to develop new methodologies such as producing fruit wines for processing of the ripe tropical fruits to minimize post harvest and production losses to generate more profits and promote the sustainable use of biomass[10]. For the production of fruit wines a general methodology is using pressed juice or pulp from fruits such as pineapples, jackfruit, pears, mango, litchi, guava, cashew apple, pomegranates cherries, plums and peaches[11]. Fruit wines and liquors are produced industrially in many countries, e.g. apple wine (cider) in France, the United Kingdom, and the United States and pear wine known as "poire´" in France[11]. Other berry and fruit wines are produced mainly for domestic use in some European Union countries such as Germany, Sweden, and Finland. We will now focus on the research findings of a few fruit juices or pulp that have been processed into wines.

JACKFRUIT

Jackfruit (Artocarpus heterophyllus Lam., Family – Moraceae) is an underutilized edible fruit in the tropics and subtropics. The versatile tree has served the needs of rural communities considerably by providing food, nutrition and many other traditional medicines to the people of the South-East Asia, Indonesia, Western part of Java and India[12]. The jackfruit is a rich source of phenolics and flavonoids which in turn have good antioxidant properties[12-14]found out that jackfruit pulp contains calcium 20 mg, phosphorus 30 mg, iron 500 mg, vitamin-A 540 I.U., thiamin 30 mg and caloric value 84 calories per 100g and prepared wine from jackfruit juice for the development of functional beverages with

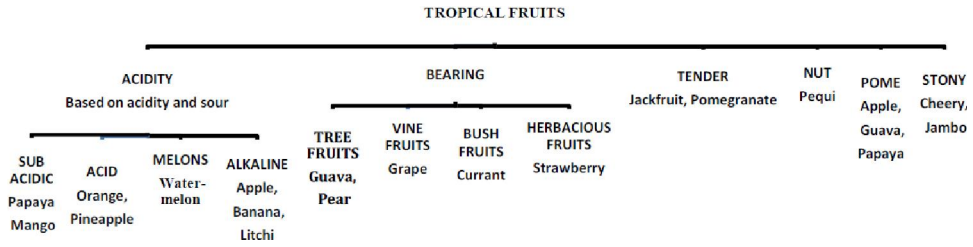

Figure 1 : Classification of tropical fruits

health beneficial properties comprising nutraceuticals and phytochemicals. The pulp slurry made from grinding the fruit having a pH of 5.5 and sugar content of 11°Brix was clarified using pectinase and fermentation process was initiated by yeast inoculums. It was incubated at 28±2°C in darkness for12 days. At the end of fermentation, the broth was centrifuged and the wine was stored at 8°C to aid the sedimentation of solid material and after analyses total flavonoids compounds in jackfruit wine was found to be 0.016 mg Rutin equivalent mL^{-1}.[13].

CASHEW APPLE

Cashew (Anacardium occidentale L., Family – Anacardiaceae) is one of the most important plantation crops in India, Brazil, Nigeria and Vietnam[15]. Unlike cashew nut kernel, which has an exclusive fine taste and a commercial attractiveness of its own, cashew "apple," despite its high nutritive values (high content of vitamin C and minerals, i.e., Ca, P, Fe)[16] and economic potential, is virtually an unknown product in the consumer market. The edible cashew apple is almost neglected in commercial terms, as compared to the nut. Cashew apple juice, for being rich in sugar with high mineral contents, is a very good raw material for alcoholic fermentation. The investigation of the alcoholic fermentation of cashew apple is a old concept[17,18]. Evident from work of [19], some Brazilian research institutes have been working together to develop a novel fermented beverage similar to wine. An enology procedure was established to obtain a type of dry white wine, called base wine formulated to produce sweet and sparkling wines, brandies and coolers. Cashew apple wine obtained is light yellow (in appearance) beverage with an alcohol content of 7.0%. It was slightly acidic (1.21-g tartaric acid/100 mL), which, together with comparatively high tannin content (1.9 ±0.22 mg/100 mL), imparted the characteristic cashew apple flavor and astringency. Lactic acid concentration in this wine was very low (2.5 mg/100 mL)[20].

GUAVA

Guava (Psidium guajava, Family-Myrtaceae) is an important tropical fruit, mostly consumed fresh. World production of guava was estimated at about 500,000 metric tons[21]. Of the South American countries, Brazil, Colombia, Mexico, and Venezuela produce significant quantities of guava. According to[22], it is one of the most important commercial fruit crops of India available twice a year and constitutes 6.2% of the total fruit production but with pertaining storage, transport problems and inadequate processing of the large quantities in peak fruiting season, it perishes at the site of the orchard particularly in rainy season. Therefore, their utilization in some form becomes absolutely essential. An alternative to the above-mentioned problem is to utilize excess guava fruits for the production of ethanol. The guava fruits which are available in abundance at low price have the potential to be utilised for production of highly acceptable fruit wine both for indigenous consumption and for export[23]. For making wine from pulp, dilution with water is essential and a dilution rate of 1:2 was found to work better than1:3. The treatment of pulp with pectinases increases the final yield of wine with about 18%[24]. Fermentation of guava pulp in the presence of pectinases yields wine with high tannin content, dark colour and an astringent taste, whereas wine prepared from guava juice obtained by only treating the pulp with pectinases for juice extraction gave wine with lower tannin content, optimum colour, flavour and an acceptable sensory quality. On Brix reaching 100°, the pomace is removed and more sugar is added (10%) to the fermenting materials and the mixture is allowed to ferment further[24]. Better wine was obtained by fermentation of guava juice compared to the guava pulp.

MANGO

Mango (Mangifera indica L., Family-Anacardiaceae) is one of the most popular tropical fruits cultivated and consumed worldwide. The world production of mango is estimated to be over 23.4 ¥ 106 MT per annum. India ranks first[25] among the world's mango producing countries, accounting for 54.2% of the total mango produced worldwide. Mango fruit commonly called "King of fruits" ranking fifth[25] in total production among major fruit crops worldwide. Production of wine from mango is one of the alternative ways to use and convert surplus production into a valuable product[26]. Mango contains proteinaceous substances, vitamins, minerals and is suitable for conversion into

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wine[27]. Preliminary screening of ten varieties of mango for wine making was reported[28]. For making wine, the fruits must first be pulped. The total suspended solids are raised to 20°B by adding cane sugar; usually 100 ppm SO_2 is used, pectinase enzyme (0.5%) is added to the pulp. The mango juice is fermented using S. cerevisiae at a rate of 10% for 7-10 days at 22°C. After racking and filtration, a sweet wine is prepared. The alcohol content of mango wines ranged from 5 to 13% and the wines normally contain low levels of tannins. Acceptable table wine was also prepared from overripe mango fruit[29]. It is reported that mango wine contains ash of 0.27g/100g, soluble solids of 5° Brix, specific gravity at 30^0C of 0.9812, Total acidity of 0.38% (as citric acid) and 12.7% (v/v) ethanol[7].

PALM

Palm (Acrocomia Mexicana, Family- Arecaceae) is indigenous to the tropical regions where palms grow, such as Africa, Asia and South America[30]. Palm juice from palm tree is a seasonal and low priced drinking juice in many of the countries like India. In such areas, the beverage plays an important role in the culture of the people. Palm sap is transparent, with a sugar content of 100–144 g/kg, a pH of 7.0–7.4 and traces of ethanol[31]. For the preparation of palm wine, the sap is obtained from decapitated inflorescence. The freshly harvested sap is sweet in taste and colourless liquid containing 10-12% sugar[32]. Further analysis revealed that the juice contains 4.20±1.4% sucrose, 3.31±0.95% glucose. The sap is allowed to ferment spontaneously for about 24 hours. To continue fermenting, sugar has to be added to the palm juice. During the fermentation process, the lactic acid bacteria lower the initial pH of the juice from 7.4 to 6.8 and after 48hour, the pH is further reduced as low as 4.0. The ethanol levels as high as 4% with a pH 3.6[31]. Palm sap wine is a source of minerals especially potassium[33]. The physicochemical characteristics of a typical palm wine as analysed by[33] were as follows: pH (4.0), alcohol (12.86%), and the minerals analysed were: phosphorus (38), sodium (28), calcium (142), magnesium (57), iron (2.5), manganese (0.5), copper (0.9), zinc (0.2) and potassium (2,540) all in ppm. The protein content of the wine was about 0.61%.

BAEL

Bael fruit (*Aegle marmelos, Family*-Rutaceae) is a tropical seasonal fruit harvested in India, Pakistan and other Asian countries[34]. The fruits of wild trees are smaller than the cultivated types and are of less commercial use[35] but fruit pulp shown to have important bioactive compounds such as carotenoids, phenolics, alkaloids, pectins, tannins, coumarins, flavonoids and terpenoids[36-39]. Bael fruits broken into two halves, pulp scooped up and seeds as well as fibres were manually removed from the pulp. The pulp was mixed with water 1:1 (w/v ratio) and juice was extracted. The juice with 12° Brix sugar content of the must was ameliorated to 20° Brix by addition of cane sugar. The pH of the must was adjusted to 4.6 by addition of 1N tartaric acid solution. The must was inoculated with starter culture of S. cerevisiae (2%, v/v), and $(NH_4)_2SO_4$ at 0.1% concentration was added as the nitrogen source[40]. Fermentation was carried out at ambient temperature for 7 days. The wine obtained is reported to have a alcohol content of 7.9% with pH 4.2. The wine has total sugar (g/100 m) 2.03g, titratable acidity (g tartaric acid/100 ml) 0.15, â-carotene (mg/100 ml) 33.00 ±0.01, ascorbic acid (mg/100 ml) 80.00 ±0.01, lactic acid (mg/100 ml) 0.64±0.06[34].

LITCHI

Litchi (Litchi chinensis Sonn. Family- Sapindaceae) is a tropical and subtropical fruit of high commercial value and has earned its popularity worldwide mainly due to its aroma and attractive red appearance. It is a tropical fruit originating from China having a red bright attractive pericarp surrounding a white gelatinous aril. The majority of the litchi crop is exported far from its production areas to European markets, which are strongly influenced by aesthetic "eye-appeal"[41]. Physicochemical characteristics of the juice were as follows: total sugar, 162 g/L; titratable acidity (expressed as tartaric acid), 3.1 g/L; and pH 4.2. With the production of litchi wine, the fermentation temperature was controlled between 12 to 14 °C until the total sugar was reduced below 3 g/L. Litchi wine had ethanol, 10.9% (v/v); titratable acidity, 6.0 g/L; volatile acidity, 0.4 g/L (expressed as acetic acid); reducing sugar, 2.1 g/L. Diato-

maceous filtration was conducted after alcoholic fermentation, and subsequently, the finished litchi wine was stored in green bottles[42].

PINEAPPLE

Pineapple (Ananas comosus L., Family-Bromeliaceae) is an important tropical fruit that is consumed in many parts of the world as fresh and processed product. In recent years it has become one of the most demanded exotic fruits. It has a high nutritive value and a rich source of vitamins A, B and C along with several minerals such as calcium, phosphorus and iron[43]. Pineapple juice has sugar of up to 22-25°Brix and can produce wine of about 12-13% alcohol, which can be preserved by pasteurisation[23]. Fresh and ripe pineapples peeled, cut in pieces and passed through a colloid mill. The milled fruit was added at 10% (w/w) to wort containing brown sugar (190 g/l), dibasic ammonium phosphate (1 g/l), and anhydrous citric acid (2 g/l). After 5 days, the wine was decanted and it was stored at 25 C for 1 month. The wine was reported to contain 10.8 alcohol (% v/v). residual extract (g/l) 12.9, total acidity (g/l as anhydrous citric acid) 4.12, volatile acidity (g/l as acetic acid) 0.82[44]. Wine from pineapple waste is made in Hawaii and Philippines to make distilled vinegar.

JAMUN

Jamun (Syzgium cumini L, Family- Myrtaceae) is an evergreen tropical tree native to India and Indonesia. It is also grown in other areas of Southeast Asia including Malaysia, Myanmar, Pakistan and Afghanistan[45]. The berry is oblong, ovoid and shinning crimson black when fully ripe with rich anthocyanin pigment. Fruits of the distinct variety are large and deliciously sweet but slightly sour[46]. The fruit can be used in making dry wine of an acceptable quality[47]. Jamun fruit with its refreshing pink to greyish flesh, balanced sugar, acid and tannin contents can suitable be used in making dry wines of an acceptable quality[47]. To prepare jamun wine, the mashes usually diluted in a 1:1 ratio, and ameliorated to 23°B with cane sugar, diammonium hydrogen phosphate is added at 0.2%, sulphur dioxide (normally up to 150 ppm,) and 0.25% pectinol enzyme. The fermentation is carried out with 2% S. cerevisiae followed by racking, filtration and bottling. The typical characteristics of Jamun wine is normally as follows: total suspended solids 2.8 ± 0.00, reducing sugar (g 100 ml-1) 0.49 ± 0.04, titratable acidity (g tartaric acid 100 ml-1)1.11 ± 0.07, anthocyanin (mg 100ml^{-1}) 60.00 ± 4.50, tannin (mg 100 ml^{-1}) 1.40 ± 0.75, lactic acid (mg 100 ml^{-1}) 0.80 ± 0.02[45].

TENDU

Tendu (Diospyros melanoxylon L., Family-Ebenaceae.) is an evergreen tropical tree. A native wild fruit found in the peninsular plains and lower hills especially in the dry deciduous forests of central, northern and western India[48]. These fruits with rich sugars, proteins, fibre and rich phytochemicals such as â-carotene, terpenoids, flavonoids, saponin and tannins add advantage to its nutritive value[49]. Tendu wine obtained had a slight yellowish appearance and the following chemical characteristics are as follows: total suspended solids 2.0±0.00, total sugar (g/100ml) 3.78±0.13, titrable acidity (g/tartaric acid/100ml) 1.32±0.52, ascorbic acid (Vit -C) (mg/g) 1.52±0.22, lactic acid (mg/100ml) 0.39±0.05,á-carotene (mg/100ml) 18.00, methanol (%) 3.5[50].

POMEGRANATE

Pomegranate (Punica granatum L., Family-Lythraceae) is a popular tropical fruit, with a myriad of health-promoting features[51]. It is useful for manufacturing wines rich in bioactive compounds[51,52]. It is also important to highlight that healthy effects have been described for pomegranate wines, probably linked to its phenolic composition[53]. Pomegranate wine was produced in accordance to[51]. Fermentation was started after adding yeast and temperature was kept at 22 °C throughout the fermentation process (9 days) with a latex glove served as pressure CO_2 release valve. Once fermentation finished, the wines were clarified and racked for one day at 4 °C. Wines were left to stabilise for 10 days in darkness at 20°C[54]. Pomegranate wine has been reported to have the following characteristics: titrable acidity (g citric acid/L) 4.56 ± 0.11, volatile acidity (g/L) 0.26 ± 0.01.

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BANANA

Banana (*Musa paradisiac*, Family- Musaceae) cultivation is exclusively tropical[55]. Banana, a seasonal and highly perishable fruit, is available all the year round. The large quantity of bananas and plantains (about 102 million MT in 2003) provides the potential for industrial use[56]. Considering the nutritional aspect, and in terms of economical value it is the number five agricultural crop in world trade. Banana fruits can also be converted into wine[57, 58] carried out preliminary studies to optimize banana juice extraction by using different levels of pectinase enzymes and different incubation periods at 28°C. Based on these studies a 0.2% pectinase addition and a 4hr incubation time were selected for obtaining the juice from the pulp. The juice was separated by centrifugation and the clear juice was used for preparation of wine[58]. The juice recovery from overripe bananas was higher (67.6%) than that from normal fruits (60.2%)[57,27]. The banana wine chemical composition reported by[57] was as follows: Total suspended solids of 10.2±0.2, acidity of 0.88±0.06%, 3.18 ±0.16% reducing sugars, 0.044±0.002% tannins and alcohol of 6.06±0.06% (v/v). Whereas[27] reported the chemical properties of a banana wine as follows: ethanol 13.98% (v/v), total acidity of 0.33% (as citric acid), specific gravity at 300C of 0.9810, soluble solids as 5.2 °Brix, an extract of 0.43g/100g and pH of 3.85.

PAPAYA

Papaya (Carica papaya, Family - Caricaceae) is tropical fruit widely grown throughout tropical and subtropical regions such as Australia, Hawaii and South East Asia[59]. Papayas are high in protein, fat, fibre and carbohydrates in comparison to other temperate fruits such as peaches[60]. It is a rich source of vitamin A, potassium and carotenoids[61]. Papaya has also been used for the production of papaya wine and alcohol content of the same has been reported to be 11.3%[62].

ANTIOXIDANT ACTIVITY OF TROPICAL FRUIT WINES

The chemical composition of wine is essential in order to establish a potential relationship and understanding its role with different beneficial biological activities enhancing human health benefits. Fruits containing a wide range of flavonoids and other phenolic compounds possess antioxidant activity. Phenolic compounds in red grape wine have been shown to inhibit in vitro oxidation of human low-density lipoprotein (LDL)[63-67]. The phenols and flavonoids compounds present in wines are known for their positive effects on inflammation[68], cardiovascular diseases[69], besides having antibacterial and antioxidant activities[70]. The effort is to highlight some of the reported antioxidant activities of other fruit wines. Some of the reported values of DPPH activity and phenolic composition of various tropical fruit wines are discussed here.

The Jack fruit wine showed high radical scavenging capacity of 69%[71] compared to that of wines prepared from lime (20.1±1.09%), tamarind (15.7±0.63%), garcinia (15.4±0.21%), rambutan (15.1 ± 0.26%), star gooseberry (14.8 ± 0.46%) fruits[72], cashew apple 7.72 %([20], mango 42 %[7], bael wine 48%[34], pineapple 36 %[44] and tendu 52 %[50] (Figure 2). Among the reported values Litchi has the highest DPPH activity of 86.7% [42]. Litchi wine with the highest DPPH activity is due to high amount of phenolic content[73]. On the other hand, a comparative study was taken for the grape wine and cashew apple wine for parameters such as total suspended solids, reducing sugar and phenol concentration and found out to be somewhat similar in both case[20]. As expected, the grape wine has the highest antioxidant activity than all other fruit wines with the reported value of DPPH Activity 93-95%[74] (Figure 2).

Several studies have revealed that the majority of the antioxidant activity of the fruit may be from compounds such as flavonoids, isoflavones, flavones, anthocyanins, catechins and other phenolics[75-80]. Polyphenols act as free radical-scavengers quenching hydroxyl radicals (·OH) or superoxide anion radicals (O·2)[81]. Further, the lower pH of the wine is highly favourable for the stability of the polyphenols as they are known to autooxidise with increase in pH[82]. It was reported that jack fruit wine contains total phenolics as 0.053 mg GAE mL^{-1}[83], the result indicated that jack fruit wine has lower levels of phenols and flavonoids as compared to red wine which contains high phenolic content averaging 2567 mg GAE L^{-1}[70]. Moderately alcoholic bael wine has a phenolic content varying slightly

TABLE1 : Comparative study of commonly occurring tropical fruit wines.

Fruit Wine	Category	Composition	Alcohol Content (% v/v)	DPPH (%)	pH	Total Phenolic Content	References
Jack Fruit	Tropical	Moisture: 77%, Carbohydrate: 18.9%, Protein: 1.9 %, Fat: 0.1%,, Fiber :1.1 g%, Mineral matter :0.8%	4.33 ± 0.12	69.44±0.34	4.37 ±0.03	0.053 ± 0.00 mg GAE mL?1	[13]
Cashew Apple	Tropical and seasonal	Moisture :85.00%, Reducing sugar: 11.80% Crude fiber : 0.64%, Ascorbic acid : 0.195% Ash : 0.33%	5.0 ± 0.25	7.72	2.92 ±0.06	0.12 ± 0.03 mg/L	[20]
Guava	Tropical	Moisture:74-87%, Total sugars : 4.2-11.1% Protein: 0.8-1.5%, Fat : 0.4-0.7% Crude fiber: 2.0-7.2%, Ash: 0.5-1.0%	±0.30	-	3.2 ±0.10	-	[24]
Mango	Tropical and seasonal	Moisture 80.78%, Sugar : 9.07% Starch : 1.07% Protein :0.44% Fat : 0.07%, Ash :0.36% Acidity: 0.30%	12.7± 0.50	42.00	2.64	537.4–202.7 mg/L	[7]
Palm	Tropical	Total Sugar 10–14.4%	4.0	-	3.6	-	[31]
Bael	Tropical	Moisture: 61.5%, Total sugars: 12 % β-Carotene: 0.95% Ascorbic acid: 1.28 %	7.87±0.31	48.00± 2.20	4.10±0.02	0.93±0.03 g/100ml	[34]
Litchi	Non-climacteric subtropical fruit	Moisture : 80.35% Sugar: 16.24% Protein: 0.76% Fat :0.10% Ash: 0.42%, Acidity :0.25%	10.9	86.7 ± 0.17	3.92 ± 0.12	0.22 g/100ml	[42]
Pineapple	Tropical and subtropical	Total sugar : 19% Soluble solids :14.0 Total acidity: 6.0%	10.8	35.6 ± 0.45	3.52	108.0mg/l gallic acid	[44]
Jamun	Tropical	Moisture: 83.20% Reducing sugar: 14.00% Fat: 0.30% Crude fibre :0.90% Ascorbic acid :0.25% Anthocyanin:0.14% Ash: 0.33%	6.00 ± 0.25	-	3.3 ± 0.06	0.22 ±0.03 g/100ml	[45]
Tendu	Tropical wild fruit	Moisture : 68.8% Total sugar : 28.6% Ascorbic acid : 2.8% β-carotene : 22.0% Ash: 0.25%	6.8	52.00	3.12	0.95 g/100ml	[50]

between the must and the wine samples (1.02 g/100 ml in must; 0.93 g/100 ml in wine)[34]. Total phenol content of the bael wine (0.93 g/100 ml) was higher than that of cashew wine (0.12 g/100 ml)[20], litchi wine (0.22 g/100ml)[73] and jamun wine (0.22 g/100 ml)[45]. Tendu wine, with the phenolic content of 0.95g/100ml is much higher than the commercial grape wines and other tropical fruit wines (TABLE 1).

CONCLUSION

A comprehensive and selective overview is pre-

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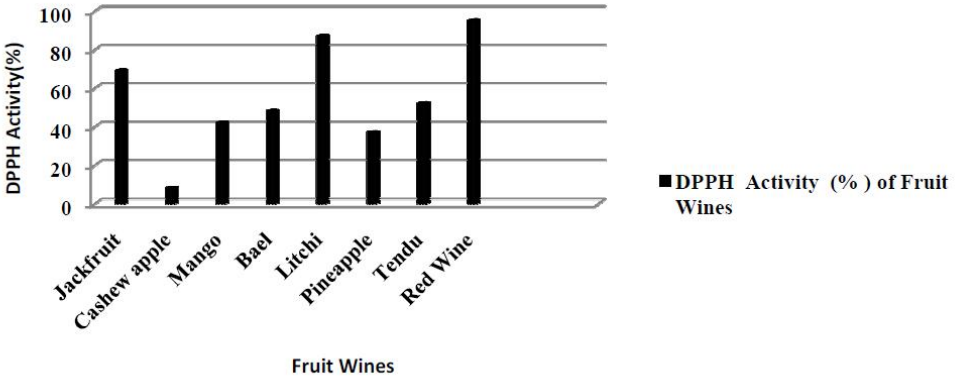

Figure 2 : Antioxidant activity of tropical fruits wine

sented on recent studies of tropical fruit wine characteristics including alcohol content, antioxidant potential, phenolic composition and other parameters for a wide assortment of exotic fruits with significant global availability potential. Most studies have been done on wine making potential of the tropical fruits and its radical scavenging activities. Tropical fruit wines as observed have fair amount of antioxidant potential and charming flavour. The variation in antioxidant potential is mainly due to various natural factors such as cultivation, vinification processes and maturation time in wood and in bottle ageing. Tropical fruit wines if consumed in low levels each day can certainly improve health as per the findings. Nonetheless, new process and technology are warranted to produce tropical fruit wines with novel flavours. While winemaking is a promising way of overripe and underutilized tropical fruit processing but to produce and create acceptability of tropical fruit wines of high quality, many researchers are concerned about appropriate parameters of fermentation and other factors of its source. This review attempts to cover a wide topic of increasing interest. It covers selected tropical fruit wines that have attracted limited attention so far due to smaller global market. In future it can be changed with changing consumers perception for high-quality nutritional content wine with diverse flavours, taste and appearance besides dominant commercial red wine which leads to a new horizon for further scope of study in tropical fruit wines leading to exploration of its potentials aiding human health.

REFERENCES

[1] M.A.Amerine, H.W.Berg, R.E.Kunkee, C.S.Ough, V.L.Singletonnes, A.D.Webb; The Technology of Winemaking **(1980)**.

[2] R.P.Vine, E.M.Harkness, T.Browning, and C. Wagner; Winemaking: From Grape Growing to Marketplace, Chapman and Hall Enology Library, New York **(1997)**.

[3] G.Avellone, V.DiGarbo, D.Campisi, R.De Simone, G.Raneli, R.Scaglione; Eur J of Clin Nutr, **60**, 41–47 **(2006)**.

[4] F.Leighton, A.Cuevas, V.Guasch, D.D.Perez, P.Strobel, A.San Martin; Drugs under Experimental and Clinical Research, **25**, 133–141**(1999).**

[5] D.Mezzano, F.Leighton, C.Martinez, G.Marshall, A.Cuevas, O.Castillo; Eur J Clin Nutr, **55(6)**, 444–451**(2001)**.

[6] F.A.N.Fernandes, S.Rodrigues, C.L.Law, A.S.Mujumdar; Food Bioprocess Technol., **4**, 163-185 **(2011)**.

[7] J.A.Pino, O.Queris; Food Chem., **125(4)**, 1141–1146 **(2011a)**.

[8] C.C.Isitua, N.I.Ibeh; Afr J Biotechnol., **9(44)**, 7521–7524 **(2010)**.

[9] J.A.Alves , L.C.de Oliveira Lima, C.A.Nunes, D.R.Dias, R.F.Schwan; J Food Sci., **76(5)**, S330-6 **(2011)**.

[10] W.F.Duarte, D.R.Dias, J.M.Oliveira, J.A.Teixeira, J.B.de Almeida e Silva, R.F.Schwan; LWT- Food Sci. and Technol., **43(10)**, 1564–1572 **(2010a)**.

[11] H.D.Belitz, W.Grosch; Food Chem., Springer-Verlag: Berlin, 774 **(1987)**.

[12] U.B.Jagtap, V.A.Bapat. J.Ethnopharmacol., **129**, 142–166 **(2010)**.

[13] U.B.Jagtap, S.R.Waghmare, V.H.Lokhande, P.Suprasanna, V.A.Bapat; Ind. Crop. Prod., **34**, 1595-1601 **(2011)**.

[14] Y.Y.Soong, P.J.Barlow; Food Chem., **88**, 411–417 **(2004)**.

[15] C.R.Muniz, M.D.F.Borges, F.D.C.O.Freire. Tropical and subtropical fruit fermented beverages. In Microbial Biotechnology in Horticulture **2**; (R.C.

Ray and O.P. Ward, eds.), in press, Science Publishers, Enfield, NH **(2006)**.
[16] O.A.Ogunmoyela; Process Biochem, March/April, 6–7 **(1983)**.
[17] O.Maldonado, C.Rolz, S.S.De Cabrera; J.Food Sci., **40(2)**, 262–265 **(1975)**.
[18] M.S.Subba Rao; Acta Horticulture, **108,** 164–171**(1985)**.
[19] M.C.Medeiros; Contribuic-a˜o ao estudo da fermentac-a˜o alcoo´lica do suco de caju para produca˜ode aguardente, M.Sc. thesis, Sa˜o Paulo, Unicamp **(1990)**.
[20] S.Mohanty, P.Ray, M.R.Swain, R.C.Ray; Fermentation of Cashew (Anacardium Occidentale L.) "Apple" Into Wine J Food Process Pres., **30**, 314–322 **(2006)**.
[21] A.Jime´nez-Escrig, M.Rinco´n, R.Pulido, F.S.Calixto; J.Agric. Food Chem., **49**, 5489-5493 **(2001)**.
[22] S.Srivastava, D.R.Modi, S.K.Garg; Bioresource Technol., **60**, 263-265 **(1997)**.
[23] V.K.Joshi, D.K.Sandhu, N.S.Thakur.; Fruit Based Alcoholic Beverages. Biotechnology: Food Fermentation, V.K. Joshi and Ashok Pandey (eds), **II**, 647-732 **(2000)**.
[24] M.C.Bardiya; Studies On fruit wines-Guava Wine. Haryana J. Hort.Sci., **3**,140 **(1974)**.
[25] S.Varakumar, Y.S.Kumar, O.V.S.Reddy; J. Food Biochem., **35**, 1538–1547 **(2011)**.
[26] L.V.A.Reddy, O.V.S.Reddy; World J. Microbiol. Biotech., **21**, 1345–1350 **(2005)**.
[27] J.O.Akingbala, G.B.Oguntimein, B.A.Olunlade, J.O.Aina; Trop. Sci., **34**, 345-352 **(1992)**.
[28] J.H.Kulkami, K.L.H.Singh,; J. Food Sci. Technol., **17**, 218 **(1980).**
[29] S.V.A.Uzochukwu, E.Balogh, O.G.Tucknot, M.J.Lewis, P.O.Ngoddy; J. Sci. Food. Agric., **64**, 405–411**(1994)**.
[30] S.Ghosh, R.Chakraborty, U.Raychaudhuri; IFRJ **19(4)**, 1633-1639 **(2012)**.
[31] O.Lasekan, A.Buettner, M.Christlbauer; Food Chem., **105**, 15–23 **(2007)**.
[32] N.Okafor; J.Appl. Bacteriol., **38**, 81**(1975)**.
[33] M.L.Balick; Econ. Bot., **44**, 84 **(1990)**.
[34] S.K.Panda, U.C.Sahu, S.K.Behera, R.C.Ray; Food Bioscience, **5**, 34-41 **(2013)**.
[35] P.C.Sharma, V.Bhatia, N.Bansal, A.Sharma; A review on bael tree, NPR., **6**, 171-178 **(2007)**.
[36] C.Parmar, M.K.Kaushal; Wild fruits of the sub-Himalayan region, New Delhi, India: Kalyani Publishers **(1982)**.
[37] C.Suvimol, A.Pranee; International Food Research Journal, **15**, 45-63 **(2008)**.
[38] S.K.Roy, D.S.Khurdiya; Other subtropical fruit. In D. K. Salunkhe, & S. S. Kadam (Eds.), Handbk of sci and tech.: production, composition, storage and processing, New York: Marcel Dekker **(1995)**.
[39] P.Maity, D.Hansda, U.Bandyopadhyay, D.K.Mishra; Indian J Exp. Biol., **47**, 849–861 **(2009)**.
[40] E.Grothea, M.Moo-Younga, Y.Chisti; Enzyme Microb Tech., **25**, 132–141**(1999)**.
[41] D.M.Holcroft, E.J.Mitcham; Postharvest Biol.Technol., **9**, 265-281 **(1996)**.
[42] Y.Wu, B.Zhu, C.Tu, C.Q.Duan; J. Agric. Food Chem., **59**, 4923–4931 **(2011)**.
[43] M.A.Hossain, S.M.M.Rahman; Food Res Int, **44**, 672–676 **(2011)**.
[44] J.A.Pino, O.Queris; Food Chem., **122**, 1241–1246 **(2011b)**.
[45] P.Chowdhury, R.C.Ray; Asean Food J, **14(1)**, 15-23 **(2007)**.
[46] R.Y.Pathak, R.A.Pathak; Improvement of minor fruits, In Chadha, K.L. and Pareek, O.P. (Eds), Advances in Horticulture, New Delhi: Malhotra Publishing House, **1**, 407- 422 **(1993)**.
[47] K.G.Shukla, M.C.Joshi, S.Yadav; N.S. J. Food Sci. Technol., **28**, 142 **(1991)**.
[48] J.L.Stewart, D.Brandis; The Forest Flora of North-West and Central India, Reprinted by Bishen Singh and Mahendra Pal Singh, Dehradun **(1992)**.
[49] M.Maridass; Ethn. Bot. Leaflets., **14**,615-625 **(2010)**.
[50] U.C.Sahu, S.K.Panda, U.B Mohapatra, R.C.Ray; Intl. J. of Food. Ferment. Technol., **2(2)**, 167-178 **(2012)**.
[51] P.Mena, A.Gironés-Vilaplana, D.A.Moreno, C.García-Viguera; Pomegranate fruit for health promotion: Myths and realities, In A. Jiménez, & C. García-Viguera (Eds.), Antioxidant Properties of Crops III, Func. Plant Sci. Biotechnol., **5(II)**, 33–42 **(2012a)**.
[52] P.Mena, A.Gironés-Vilaplana, N.Martí, C.García-Viguera; Food Chem., **133(1)**, 108–115 **(2012b)**.
[53] S.Y.Schubert, E.P.Lansky, I.Neeman; J Ethnopharmacol., **66(1)**, 11–17 **(1999)**.
[54] W.F.Duarte, D.R.Dias, J.M.Oliveira, M.Vilanova, J.A.Teixeira, J.B.A. e Silva; Food Res. Int., **43(9)**, 2303–2314 **(2010b)**.
[55] A.Lassoudie're. Le bananier et sa culture, France: Editions QUAE **(2007)**.

Review

[56] FAO, Agrostat, Production Yearbook, FAO, Rome, Italy **(2003)**.

[57] M.P.Kotecha, R.N.Adsule, S.S.Kadam; Beverage Food World, 21-28 **(1994)**.

[58] B.S.Kundu, M.C.Bardiya, P.Tauro; Haryana J. Hort. Sci., **5**, 160 **(1976)**.

[59] P.R.Lee, B.Yu, P.Curran, S.Q.Liu; Nutrition & Food Science, **40**, 566-580 **(2010)**.

[60] R.N.Peterson.; Pawpaw (Asimina), in Moore, N.J. and Ballington, J.R. (Eds), Genetic Resources of Temperature Fruit and Nut Crops, International Society for Horticultural Science, Wageningen, 569-900 **(1991)**.

[61] T.Richardson, D.B.Hyslop; ''Enzymes'', in Fenema, O.R. (Ed.), Food Chemistry, Marcel Dekker Incorporated, New York, NY, 35-8 **(1992)**.

[62] C.Maragatham, A.Panneerselvam; J Appl Microbiol., **5(2)**, 967-969 **(2011)**.

[63] E.N.Frankel, A.L.Waterhouse, P.L.Teissedre; J. Agric, Food Chem., **43**, 890-894 **(1995)**.

[64] J.E.Kinsella, E.Frankel, B.German, J.Kanner; Food Technol., **47**, 85-89 **(1993)**.

[65] J.Kanner, E.Frankel, R.Granit, B.German, J.E.Kinsella; J. Agric. Food Chem., **42**, 64-69 **(1994)**.

[66] P.L.Teissedre, E.N.Frankel, A.L.Waterhouse, H.Peleg, J.B.German; J. Sci. Food Agric., **70**, 55-61**(1996)**.

[67] R.Abu-Amsha, K.D.Croft, I.B.Puddey, J.M.Proudfoot, L.J.Beilin; Clin. Sci., **91**, 449-458 **(1996)**.

[68] M.N.Xanthopoulou, E.Fragopoulou, K.Kalathara, T.Nomikos, H.C.Karantonis, S.Antonopoulou; Food Chem., **120**, 665–672 **(2010)**.

[69] J.C.Stoclet, T.Chataigneau, M.Ndiaye, M.H.Oak, J.El Bedoui, M.Chataigneau; Eur. J. Pharmacol., 500, 299–313 **(2004)**.

[70] J.Piljac, S.Martinez, L.Valek, T.Stip¡cevic, K.Kova¡cevic Gani; Food Technol. Biotechnol., **43**, 271–276 **(2005)**.

[71] U.B.Jagtap, S.R.Waghmare, V.H.Lokhande, P.Suprasanna, V.A.Bapat; Ind. Crop. Prod., **34**, 1595– 1601 **(2011)**.

[72] N.Nuengchamnong, K.Ingkaninan; Food Chem., **118**,147–152 **(2010)**.

[73] K.K.Kumar, M.R.Swain, S.H.Panda, U.C.Sahoo, R.C.Ray; Food, **2**, 43–47 **(2008)**.

[74] I.M.Heinonen, P.J.Lehtonen, A.I.Hopia; J.Agric. Food. Chem., **46(1)**, 25–31**(1998)**.

[75] M.P.Kahkonen, A.I.Hopia, H.J.Vuorela; J. Agr. Chem., **47**, 3954"3962 **(1999)**.

[76] M.Alothman, R.Bhat, A.A.Karim, A; Food Chem., **115**, 785"788 **(2009)**.

[77] M.Mhatre, J.Tilak-Jain, S.De, T.P.A. Devasagayam; Food Chem Toxicol., **47**, 2696"2702 **(2009b)**.

[78] M.Mhatre, L.Nagi, T.R.Ganapathi; Int J Fruit Sci., **9**, 1"9 **(2009a)**.

[79] M.Isabelle, B.L.Lee, M.T.Lim, M.T.Koh, D.Huang, C.Nam; Food Chem., **123**, 77-84 **(2010)**.

[80] H.E.O.Danino, S.Gottlieb, M.Grossman, Bergman; Food Res. Int., **42(9)**, 1273-1280 **(2009)**.

[81] G.Sichel, C.Corsaro, M.Scalia, A.J.Dibilio, R.P.Bonomo; Free Radical Biol. Med., **11**, 1–8 **(1991)**.

[82] M.Mochizuki, S.Yamazaki, K.Kano, T.Ikeda; Biochimica et Biophysica Acta, **1569**, 35–44 **(2002)**.

[83] U.B.Jagtap, S.N.Panaskar, V.A.Bapat; Plant Foods Hum. Nutr, **65**, 99–104 **(2010)**.