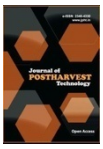

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RESEARCH ARTICLE

# Physico-chemical characteristics and sensory evaluation of Sikkim mandarin wine

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## ABSTRACT

The present study entitled “Physico-chemical characteristics and sensory evaluation of Sikkim Mandarin wine by using three different types of Yeast” was carried out at Dept. Of Horticulture, Sikkim University, Gangtok during 2019-2021 with the objectives to study the effect of initial and final Total Soluble Solids in Sikkim mandarin wine, To study the alcohol content in the Sikkim mandarin wine from initial maturation (0 days) to final maturation (4 months) and to study the sensory effect of three different types of yeast in prepared Sikkim mandarin wine.The maturation alcohol content of all the wine increased while TSS decreased during maturation. The fermentation of treated juice, initial sugar concentration played an important role. The fermentation of efficiency of yeast decreased with increase in the initial sugar concentration and bitterness in wine was observed. There is a good potential for making wine from Sikkim mandarin fruits since the TSS content of the juice ranges between 10-12$^0$Brix. It is recommended to add cane sugar to have suitable alcohol content in the final wine to remove bitterness and also can added different flavour to have different taste. The result of the present investigation indicated that the wine made from Sikkim mandarin having Treatment $T_{11}$ (TSS of 28$^0$Brix and $SO_2$ 100 ppm), fermentation by Brewer’s Yeast and matured for 4 months had the highest overall sensory score of 7/10 and having 10.05% ethanol content.

**Keywords:** Sikkim mandarin, active dry yeast, brewer’s yeast, Marcha (local yeast), wine

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## INTRODUCTION

Fruits play an important role in our lives. It is not only important for nutritional aspect but also has social, cultural, religious and economic value. The different climatic conditions and geographical features of our country make it suitable for growing various kinds of fruits, vegetables, spices and plantation crops. India covers about 2.4% of world’s geographical area and 4% of water resources and supports 16 % of the world’s human population. The share of agriculture in GDP increased to 19.9% in 2020-21from 17.8% in 2019-20. The last time the contribution of the Agriculture sector was at 20% was in 2003-04 as reported by Kapil (2021). The GDP of the nation can be increased with the development in horticultural sector. About 65% of the population of the country is engaged in agricultural sector.

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The North Eastern Region of India is one of the richest reservoir of genetic variability and diversity of different horticultural crops that exists in plant type, morphological and physiological variations, reactions to diseases and pests, adaptability and distribution. The region spreads over an area of 2,620,230 $km^2$ (8% of country's geographical area) and consists of eight states (Mitra and Roy, 2014). As per Horticultural Statistics at a Glance (2018) fruit crops covers an area of 6.506 million hectares with total production of 97.358 million tonnes. India is the second largest producer of fruits and vegetables in the world after China. The main causes of postharvest losses are improper harvesting equipments, lack of storage facilities and lack of cold chain in the whole process of post-harvest handling losses in fruits have been estimated to 20-35%.

Mandarin is the most common among citrus fruit in India. It belongs to family Rutaceae. It occupies nearly 50% of the total citrus area in India. Mandarin group include all types' loose Jacket oranges commonly called Santra or Mandarin such as Nagpur Santra, Coorg Mandarin, Khasi Mandarin. Citrus fruit fresh as well as their juice are popular

worldwide due to excellent flavour and nutritional value. Sikkim mandarin represents the most important commercial fruit of Sikkim. Sikkim mandarin is similar to the Nepal or Assam or Darjeeling. Mandarin (*Citrus reticulata*) is a highly polyembryonic species, having medium size upright trees. In Sikkim, mandarin is cultivated from time immemorial. It is a native fruit of Sikkim and is very popular in Kolkata and Siliguri market. The origin of *Citrus reticulate* is China, though it is grown in many states of India. In Asia, it is mostly grown in Japan, Southern China and India. Citrus fruits are grown in tropical and subtropical regions of the World, especially in USA, Brazil and China. Mandarin is grown in India in the state of Maharashtra, Madhya Pradesh, Tamil Nadu, Assam, Orissa, West Bengal, Rajasthan, Nagaland, Mizoram, Arunachal Pradesh, Karnataka, Punjab, and Tripura. The valley of Teesta and Rangeet Rivers and their tributaries of Sikkim and adjoining district of West Bengal offer an ideal Himalayan climate for the cultivation of Sikkim Mandarin. Mandarin are grown in the region Coorg ( Karnataka) , Khasi Mandarin is extensively grown in Khasi, Jaintia and Lushia hills and the district of Cachar, Kamrup, Goalpara, Darrange and Sibsagar. In Sikkim mandarin orange is cultivated in an area of about 6,300 hectares with a total average annual production of about 17,190 tonnes. The important orange producing areas are Teesta and Rangeet river valley within the evaluation of range 600m to 1500m above mean sea level. Tashiding,Gyalshing, Chakung, Barthang, Omchung, Rinchenpong, Chinthang, Jimberbong, Tijyah, lingcham, Kurtak (West Sikkim) Tarkku,Tokal, Burmok, Turuk, Kewzing, Lengmoo, Sangmoo, Yangang ,Pokyong, Ruley Pani, Namthang, Sambuk (South Sikkim) Nazitam, Sang, SimGyathang (North Sikkim) are orange growing areas of Sikkim. Sikkim mandarin dominates the citrus family and is the leading cash crop of the mid hills of Sikkim Himalaya with attractive fruit colour, size and good table and processing qualities. Presently 95% of the production is sold as fresh fruits in India. The remaining 5% of production only is processed whereas the post harvest losses which are an approximate of25-30% can also benefit the growers through making of the art post harvest and value addition infrastructure.

Mandarin is sold as fresh fruit from October to February in Sikkim. The fruit has shelf life of 4-5 days only at normal temperature and up to 2-3 weeks under refrigerated condition. Mandarin is a good source of Vitamin C and folate, a source of Vitamin A and B beside this the fruit also contain Sodium, Potassium, Magnesium, Copper, Sulphur and Chlorine. Sikkim mandarin as fresh fruits can be used for preparation of processed products like wine, canned juices, beverages but here is a problem of bitterness and considerable work has been done to reduce the bitterness in preparation of wine from Kinnow fruit. Due to the presence of bitter glucosides 'Naringine' and 'Limonin' the juice turns bitter right after its extraction from fruits when it comes into contact with air. This limits the processing ability of mandarin into juices and other beverages. As a result of that large quantity of the fruits that are not utilised goes waste due to lack of processing possibilities. Hence, production of wine is an available alternative way to which will minimize seasonal glut, related to post harvest losses and price fluctuation in the market. It has water, alcohol, pigments, esters, vitamins, carbohydrates, minerals acids, and tannins with medicinal curing value. In wines alcohol is a

micronutrient and is an energy source, has a power of providing calories for all essential biological works of the human cells, energy for physical work and thermogenesis (Bission et al., 1995). Fruit wines are produced and consumed in large quantities in all advanced countries in the world. The conversion of raw food material into finished products is often considered to be one of the best example of "value added" processing Indian wine exports are going up every year in the world and spread very fast with creating awareness of Indian wine in international Market. Wine has been evaluated to be able to impart better organoleptic quality by Pure *Saccharomyces cerevisiae*. Fruits wines are undistilled fruit based fermented beverages made from grapes and other fruits by alcoholic fermentation of their juice under controlled condition by yeast (S*acchoromyces cerevisiae*), subsequent aging (maturation and clarification (Joshi et al., 1997). A wine contains ethyl alcohol, sugars, organic acids, tannin, aldehyde, esters, amino acids, minerals, vitamins, pigments and flavouring compound (Amerine et al.,1980). Different studies have found that the beneficial effects of wine consumption due to presence of phenolic substances and alcohol in it which protects the human body from attack of free radical and increase the high density lipid ( HDL) in the body ( Joshi et al.1997; Joshi et al.2012) Generally, the use of suitable yeast culture can be used to increase desirable flavour compounds while maintaining the fermentation reliability not only for grapes wine but also for other fruit wines like mandarin wine, apple, peach, pomegranate etc (Joshi et al., 2012). The production of wine increase in initial TSS, the fermentation rates decreased from mandarin is another alternative to reduce the wastage of fruit and also to increase the economic turnover from the fruit. Mandarin wine has been prepared earlier (Amerine et al., 1980) but there is no proper documentation of optimization of various factors involved. Very limited work has been reported on utilization of mandarin Fruits. The present experiment was conducted at Department of Horticulture, Sikkim University, Gangtok to investigate the feasibility of production of wine from Sikkim Mandarin and to evaluate them with the objectives to study the effect of initial and final Total Soluble Solids in Sikkim mandarin wine, to study the alcohol content in the Sikkim mandarin wine from initial maturation (0 day) to final maturation (4 months) and to study the sensory effect of three different types of yeast in prepared Sikkim mandarin wine.

## MATERIALS AND METHODS

The medium sized Sikkim mandarin was collected from organic market of Gangtok Lal Bazaar, which the fruits were brought from Central Pandam area, East Sikkim. Juice was extracted with the help of hand juice extractor. Cane sugar used to obtained better taste of the must for preparation of Wine was procured from the 6$^{th}$ mile, market Gangtok. Therefore attempt was to produce quality wine by using three different types of yeast like Brewer's yeast, Active dry yeast and Marcha (local yeast from Sikkim) and also by using different sugar concentration and different concentration of $SO_2$. Quality wine was made by using three different types of yeast like Brewer's yeast, Active dry yeast and Marcha (local yeast from Sikkim) and also by using different sugar concentration and different concentration of $SO_2$ . The consumption of alcoholic beverages, made by using fermentation using amylolytic starter inocula commonly called as amylolytic starter. The amylolytic starter is a round to flattened ball of mixed dough containing various wild and domesticated plant parts and amylolytic and alcohol producing yeast, starch degrading moulds and lactic acid bacteria. Varieties of ethnic amylolytic starter, are prepared such as Marcha of Sikkim and the Darjeeling hills of India. Amylolytic starters can be found in different regions of the Eastern Himalayas and North east India (Anupama et al. 2018). Marcha is a dry flat creamy white solid ball like starter of different size and shape traditionally prepared in Sikkim and the Darjeeling hills in the state of west Bengal in india which is used to ferment starchy material into various ethnic fermented beverages and alcoholic drinks. Marcha is prepared from Glutinous rice (*Oryza sativa*) is soaked in water for 8-10 hours at favourable temperature. After soaking rice is crushed in a foot driven very heavy wooden mortar pestle. Wild herbs such as roots of guliyo jara or chitu (*Plumbago jalenica*) leaves of bheemsen paate (*Buddleja asiatica*) , ginger and red chilli (2-3 pieces) are crushed and added to the powdered rice for fragrance and keeping away from pest . Mixtures are then mixed with water to make thick paste or dough. These balls are then dusted with the old marcha which are used as an inoculums. The

freshly flattened balls are kept on the leaves of fern (*Glaphyloteriolopsise rubescens*) and covered with the ferns and fermented at room temperatures for 24 hrs. After fermentation, ferns are removed and balls are collected and dried in the sun or kept at room temperature for about 5 days. The dried marcha balls were ready to be used. Active dry yeast it's a type of dry yeast that's granular, with a consistency similar to cornmeal. It's a living organism that's dormant until proofed, or dissolved in a small amount of lukewarm water. It's then added to the rest of the ingredients, where it causes dough to rise. Active dry yeast is typically sold in individual packets. The active dry yeast used was Generic and of Indian origin Brewer's yeast has a bitter taste. Brewer's yeast is also used as a nutritional supplement. It's a rich source of chromium, which may help your body maintain normal blood sugar levels. It's also a source of B vitamins. Brewer's yeast can provide energy and may help maintain healthy skin, hair, eyes and mouth. It may be effective at supporting the nervous system and enhancing the immune system. The chromium in Brewer's yeast may help control sugar levels for patients with Type 2 diabetes by improving glucose tolerance. Ingredient type used was Baker's yeast (brand name Bake King).

**Rehydration of Yeast**

The yeast (active dry yeast and brewer's yeast was rehydrated as per the direction of the manufacturer and for marcha (local yeast) was rehydrated taking the ideas of local farmers respectively. To 50ml of sterile water temperature 40ºC add 10g Di-ammonium hydrogen phosphate as yeast protector was added by stirring. When the temperature came down to 35ºC, 10 gram of active dry yeast, brewer's and local yeast (marcha) was respectively added and let it rest for 20 minutes for rehydration.

**Fruit (*Citrus reticulata*) collection**

Fully ripened fruits of mandarin (total 60 Kg) were taken from Sikkim. The fruits of mandarin (60 kg) were purchased from Lal Bazaar (Organic Market) and place of collection was Central Pandam, Sikkim.

**Preparation and maturation of Wines**

Juice was extracted from ripe mandarin fruits by using hand Juice Extractor. The TSS of the juice was adjusted to 20° 24°and 28°BrixSO2@100,150ppm, 24°Brix by adding cane sugar. $SO_2$ was added @100 and 150 ppm by adding calculated quantity of potassium metabisulphite to have 18 different treatments. Then rehydrated yeast culture was added to each treatment @ 10ml per 250 ml of must contained in conical flasks. Active Yeast, Brewer's yeast and local Yeast (marcha) culture was added @ 5% and the must was allowed to ferment. The must was allowed to ferment with air lock assembly 'on' to create anaerobic condition. After the fermentation was completed, the wines were siphoned. To ensure better clarification, siphoning was done 2-3 times. The wines were then blended with sugar to make these Wines were then pasteurised and bottled and left for maturation at 10℃ for a period of 4 Months.All the must were kept in glass container ammonium dihydrogen Phosphate GR was added at the 0.1% as nitrogen source to all the observation and parameter to be recorded. The active yeast, Brewyer's yeast and local yeast (Marcha) were used in study.

**Treatment details**

Must of different treatments of TSS and $SO_2$ concentration were prepared. The initial juice TSS 10.5 °Brix was raised to different level 20, 24, and 28° Brix by addition of sugar. The following treatment combinations were used in study with three replications.

T1- Active dry yeast +TSS ($20^0$Bx) + $SO_2$@100ppm

T2- Active dry yeast + TSS ($20^0$Bx) + $SO_2$ @150 ppm

T3- Active dry yeast + TSS ( $24^0$Bx) +$SO_2$ @100ppm

T4- Active dry yeast + TSS ($24^0$Bx) +$SO_2$ @150ppm

T5- Active dry yeast + TSS ( $28^0$Bx) + $SO_2$ @100ppm

T6- Active dry yeast + TSS ( $28^0$Bx) + $SO_2$@150ppm

T7- Brewer's yeast + TSS ($20^0$Bx)+ $SO_2$ @100ppm

T8-Brewer's yeast + TSS ( $20^0$Bx)+ $SO_2$@150ppm

T9- Brewer's yeast + TSS ($24^0$Bx )+ $SO_2$ @100ppm

T10- Brewer's yeast +TSS ( $24^0$Bx) + $SO_2$ @150ppm

T11- Brewer's yeast +TSS ( $28^0$Bx)+ $SO_2$ @100 ppm

T12- Brewer's yeast + TSS ($28^0$Bx) $SO_2$ @150ppm

T13- Local yeast + TSS ($20^0$Bx $SO_2$ @100ppm

T14- Local yeast + TSS ( $20^0$Bx) $SO_2$ @150ppm

T15- Local yeast + TSS ( $24^0$Bx)$SO_2$ @100ppm

T16- Local yeast + TSS ($24^0$Bx) SO2@150ppm

T17-Local yeast + TSS ($28^0$Bx) $SO_2$ @100ppm

T18-Local yeast + TSS ($28^0$Bx) $SO_2$ @150ppm

**Organoleptic Test**

Organoleptic test was conducted to check the quality and acceptability of the wine ( made from Brewer's yeast, Active Dry Yeast, local yeast (marcha) prepared from Mandarin must (Juice).The test was done with 5 different age groups- Group 1 (20-30 yrs ), Group 2 (30-40), Group 3 (40-50), Group 4 (50-60), Group 5 (60-70)yrs. Marking of the wine was done for its taste, aroma, texture, colour ,astringency for different treatment. The marking scale was set from 1 to 10 with specific category. The category for different marking scale was as follows:

[10-excellent, **9**-very good,**8** -good, **7**-little above satisfied, **6**-satisfied, **5**-average, **4**-below average, **3**-not so bad,**2**- bad, **1**-worst]. The hedonic scale reading on 9 point scale was also taken for best treatment wine.

**Ascorbic acid estimation**

Ascorbic acid was estimated for fresh Sikkim Mandarin. It becomes essential to check the content of ascorbic acid in it. Ascorbic acid was estimated by using 2, 6-Dichlorophenol- Indophenol Visual Titration Method. The colour of the dye change from blue (in alkaline solution) and red (in acid solution) to colourless due to ascorbic acid. This technique is practically specific for ascorbic acid in the solution in the pH range of 1-3.5. Ascorbic acid content of the sample was calculated using the following formula:

Mg of ascorbic acid per 100gm or ml

= (Titre X Dye factor X Volume made up X 100)/(aliquot of extract taken for estimation X Volume of sample taken for estimation)

**Hydrometer reading and measuring the alcohol content and pH assessment**

The use of a hydrometer is necessary to calculate the alcohol by volume (ABV)content of wine. Prior to fermentation, wine will contain sugars which will make the liquid more dense and note hydrometer will float higher in the liquid in water and will therefore give a higher hydrometer reading .When the wine is undergoing fermentation the sugars in the liquid are converted by yeast into alcohol and carbon dioxide. Alcohol in water is less than sugar in water and so this will result in a change in the specific gravity and the hydrometer will sink in the liquid compared to the starting gravity. It will now have specific gravity closer to water. The wine has finished fermentation where the hydrometer reading remains constant over a period of two days and does not decrease any further. This reading is called the final gravity or (FG)and is used, in conjunction with the starting gravity, to work out the alcohol by volume content of the liquid. For Wines the final gravity is around 0.990-1.000. It is worth noting that the final gravity of wine will let you know if it's going to be dry, medium- dry or sweet.

ABV= (Starting Specific gravity of the wine –Final Specific gravity)/0.36

The hydrometer was carefully inserted into the liquid, was held at the top of the stem, and was released when it was approximately at its position of equilibrium. Using a suitable thermometer, the temperature of the liquid should be taken immediately after taking the hydrometer reading. For pH measurement, pH meter and standard buffer solution (pH 4.0 and 7.0) were required.

**RESULTS AND DISCUSSION**

The physico-chemical characteristics of fresh mandarin fruits have been given in Table 1.

**Table 1: Physico-chemical characteristics of fresh mandarin fruits**

| Particulars | Value |
|---|---|
| Average fruit weight (g) | 105 |
| TSS (Brix) | 10.5 |
| pH | 3.8 |
| Ascorbic acid (mg/100ml) | 35 |

**TSS**

Table 2 shows the changes in TSS of mandarin wine before maturation, maturation and after maturation. At 0 month, TSS ranged between 7-11.3 and the highest TSS was observed in wine of $T_{11}$(Brewer's yeast +TSS ( 28°Bx)+ $SO_2$ @100 ppm ) and $T_{12}$ ( Brewer's yeast + TSS (28° Bx) $SO_2$ @150ppm). The lowest TSS was however observed in $T_1$ (Active yeast +TSS (20°Bx) + $SO_2$@100ppm) and $T_{13}$ (Local yeast + TSS (20°Bx $SO_2$ @100ppm). During maturation, a trend of decrease in TSS was observed. The decrease in TSS content during the period of maturation of wine may be due to precipitation of soluble solids during interaction of various components (Holegar et al., 2016).

At two months stage, TSS ranged between 6.6-9.9 and the highest TSS was observed in $T_{12}$(Brewer's yeast + TSS (28° Bx) $SO_2$ @150ppm). The lowest TSS was however observed in wine of initial TSS 20°Brix of Treatment $T_1$ (Active dry yeast +TSS (20°Bx) + $SO_2$@100ppm) and $T_{13}$ (Local yeast + TSS (20°Bx $SO_2$ @100ppm).During maturation, a trend of decrease in TSS was observed. The decrease in TSS content during the period of maturation of wine may be due to precipitation of soluble solids during interaction of various components (Holegar et al., 2016). At 4 months, TSS ranged between 5.2-9.1 and the highest TSS was observed in treatment 6(Active dry yeast + TSS ( 28°Bx) + $SO_2$@150ppm) and $T_{12}$ (Brewer's yeast + TSS (28° Bx) $SO_2$ @150ppm). The lowest TSS was however observed in $T_7$ (Brewer's yeast + TSS (20°Bx)+ $SO_2$ @100ppm). During maturation, a trend of decrease in TSS was observed. The decrease in TSS content during the period of maturation may be due to precipitation of soluble solids during the interaction of various components (Holegar et al., 2016)

**pH**

It is also evident from Table 2 that pH variation was observed during maturation of mandarin wine. At 0 month, the range of pH between 2.7-4.1. Highest pH was recorded in $T_8$ (Brewer's yeast + TSS ( 20°Bx)+ $SO_2$@150ppm) and $T_{18}$ (Local yeast + TSS (28° Bx) $SO_2$ @150ppm) and lowest pH was observed in $T_4$ (Active yeast + TSS (24°Bx) +$SO_2$ @150ppm). At 2 months, the range of pH between 3.34-4.86. Highest pH was recorded in treatment $T_8$(Brewer's yeast + TSS ( 20°Bx)+ $SO_2$@150ppm) and lowest was observed in $T_9$ (Brewer's yeast + TSS (24°Bx )+ $SO_2$ @100ppm). At 4 months, the range of pH between 3.32-4.33). Highest pH was observed in $T_{12}$(Brewer's yeast + TSS (28° Bx) $SO_2$ @150ppm) and lowest pH was recorded in $T_9$ (Brewer's yeast + TSS (24°Bx )+ $SO_2$ @100ppm.

**Table 2. Physico-chemical analysis of wine (TSS, pH and Alcohol % at 0, 2 and 4 months of preparation)**

| Treatment no. | Treatments details | **Before maturation 0 month** | | | **Maturation 2 months** | | | **After maturation 4 months** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **TSS** | **pH** | **Alcohol %** | **TSS** | **pH** | **Alcohol %** | **TSS** | **pH** | **Alcohol %** |
| T1 | Active dry yeast +TSS (20°Bx) + $SO_2$@100ppm. | 7.0 | 3.98 | 7.2 | 6.6 | 3.93 | 7.40 | 6.6 | 3.990 | 7.70 |
| T2 | Active dry yeast + TSS (20°Bx) + $SO_2$ @150 ppm. | 7.133 | 3.96 | 7.5 | 6.700 | 3.98 | 7.70 | 6.70 | 4.010 | 7.80 |
| T3 | Active dry yeast + TSS ( 24°Bx) +$SO_2$ @100ppm. | 7.60 | 4.00 | 8.8 | 7.400 | 3.95 | 8.90 | 7.20 | 3.930 | 9.20 |
| T4 | Active dry yeast + TSS (24°Bx) +$SO_2$ @150ppm. | 7.700 | 2.687 | 8.900 | 7.467 | 3.91 | 9.0 | 7.30 | 3.880 | 9.30 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| T5 | Active dry yeast + TSS ( 28°Bx) + $SO_2$ @100ppm. | 9.20 | 3.097 | 10.3 | 9.200 | 4.08 | 11.0 | 9.00 | 4.020 | 11.20 |
| T6 | Active dry yeast + TSS ( 28°Bx) + $SO_2$@150ppm. | 9.300 | 4.080 | 10.0 | 9.300 | 4.07 | 9.90 | 9.10 | 4.010 | 10.20 |
| T7 | Brewer's yeast + TSS (20°Bx)+ $SO_2$ @100ppm. | 10.30 | 4.090 | 7.7 | 7.6 | 4.13 | 8.20 | 5.20 | 4.140 | 8.50 |
| T8 | Brewer's yeast + TSS ( 20°Bx)+ $SO_2$@150ppm. | 10.40 | 4.120 | 8.000 | 7.70 | 4.86 | 8.300 | 5.30 | 4.130 | 8.40 |
| T9 | Brewer's yeast + TSS (24°Bx )+ $SO_2$ @100ppm. | 11.033 | 3.98 | 8.9 | 8.50 | 3.34 | 9.000 | 7.10 | 3.320 | 9.90 |
| T10 | Brewer's yeast +TSS ( 24°Bx) + $SO_2$ @150ppm | 11.20 | 3.97 | 8.80 | 8.60 | 3.42 | 9.100 | 7.20 | 3.783 | 9.70 |
| T11 | Brewer's yeast +TSS ( 28°Bx)+ $SO_2$ @100 ppm | 11.30 | 3.707 | 10.30 | 9.80 | 4.07 | 10.040 | 9.000 | 4.15 | 10.070 |
| T12 | T12- Brewer's yeast + TSS (28° Bx) $SO_2$ @150ppm | 11.30 | 4.06 | 10.40 | 9.90 | 4.08 | 10.050 | 9.100 | 4.33 | 10.06 |
| T13 | Local yeast + TSS (20°Bx $SO_2$ @100ppm | 7.0 | 3.70 | 6.50 | 6.60 | 4.04 | 7.20 | 6.400 | 4.00 | 7.70 |
| T14 | Local yeast + TSS ( 20°Bx) $SO_2$ @150ppm. | 7.10 | 3.98 | 6.80 | 6.70 | 4.02 | 7.30 | 6.500 | 3.950 | 7.80 |
| T15 | Local yeast + TSS ( 24° Bx)$SO_2$ @100ppm. | 7.80 | 3.474 | 6.60 | 7.40 | 3.87 | 7.50 | 7.300 | 3.81 | 7.90 |
| T16 | Local yeast + TSS (24 °Bx) SO2@150ppm. | 7.90 | 3.76 | 6.70 | 7.50 | 3.34 | 7.60 | 7.400 | 3.76 | 8.00 |
| T17 | Local yeast + TSS (28°Bx) $SO_2$ @100ppm. | 9.20 | 4.073 | 7.20 | 8.70 | 4.05 | 7.80 | 8.500 | 4.07 | 8.10 |
| T18 | Local yeast + TSS (28° Bx) $SO_2$ @150ppm. | 9.30 | 4.12 | 7.70 | 9.133 | 4.10 | 8.00 | 8.600 | 4.09 | 8.20 |
| **CD=** | | **0.334** | **0.379** | **0.333** | **0.436** | **0.054** | **0.304** | **0.333** | **0.222** | **0.314** |
| **SE (m)** | | **0.116** | **0.131** | **0.115** | **0.151** | **0.019** | **0.105** | **0.115** | **0.077** | **0.109** |

**Ethanol content**

It is also clear from same table that ethanol content ranged between 6.5-10.4% (v/v) at 0 months. The highest ethanol content of 10.4% in $T_{12}$ (Brewer's yeast + TSS (28° Bx) $SO_2$ @150ppm). while the lowest ethanol content of 6.5 % in $T_{13}$(Local yeast + TSS (20°Bx $SO_2$ @100ppm). The alcohol content in wines increase slightly which could be due to conversion of sugars into alcohol due to secondary fermentation (Shukla et al., 1991). Ethanol content at 2 months ranged between 7.2-11.0% . The highest ethanol content of 11.0% in treatment T5 (Active dry yeast + TSS ( 28°Bx) + $SO_2$ @100ppm), while the lowest ethanol

content of 7.2% took place in $T_{13}$ (Local yeast + TSS (20°Bx $SO_2$ @100ppm). After the completion of maturation of 2 months. It was observed that the alcohol content in wines increase slightly which could be due to conversion of sugars into alcohol due to secondary fermentation (Shukla etal., 1991). Ethanol content at 4 months ranged between 7.7-11.2% The highest ethanol content of 11% in $T_5$(Active dry yeast + TSS ( 28°Bx) + $SO_2$ @100ppm), while the lowest ethanol content of 7.7% took place in $T_1$(Active dry yeast +TSS (20°Bx) + $SO_2$@100ppm) and $T_{13}$ (Local yeast + TSS (20°Bx $SO_2$ @100ppm). After the completion of maturation of 4 months. It was observed that the alcohol content in wines increase slightly which could be due to conversion of sugars into alcohol due to secondary fermentation (Shukla et al., 1991). The ethanol content of mandarin wine indicated that the wine prepared can be categorized as table wine.

**Table 3**: **Organoleptic test of mandarin wine**

| Treatment | Treatment no. and details | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 | Active dry yeast +TSS ($20^0$Bx) + $SO_2$@100ppm. | 6 | 6 | 3 | 3 | 5 | 5 | 5 | 5 | 8 | 8 | 5.4 |
| T2 | Active dry yeast + TSS ($20^0$Bx) + $SO_2$ @150 ppm. | 6 | 6 | 4 | 4 | 5 | 5 | 6 | 6 | 8 | 8 | 5.8 |
| T3 | Active dry yeast + TSS ( $24^0$Bx) +$SO_2$ @100ppm. | 7 | 7 | 6 | 6 | 6 | 6 | 4 | 4 | 7 | 7 | 6 |
| T4 | Active dry yeast + TSS ($24^0$Bx) +$SO_2$ @150ppm. | 7 | 7 | 6 | 6 | 6 | 6 | 8 | 8 | 7 | 7 | 6.8 |
| T5 | Active dry yeast + TSS ( $28^0$Bx) + $SO_2$ @100ppm. | 8 | 8 | 7 | 7 | 7 | 7 | 6 | 6 | 8 | 8 | 7.2 |
| T6 | Active dry yeast + TSS ( $28^0$Bx) + $SO_2$@150ppm. | 8 | 8 | 3 | 3 | 7 | 7 | 9 | 9 | 7 | 7 | 6.8 |
| T7 | Brewer's yeast + TSS ($20^0$Bx)+ $SO_2$ @100ppm. | 8 | 8 | 3 | 3 | 6 | 6 | 7 | 7 | 6 | 6 | 6 |
| T8 | Brewer's yeast + TSS ( $20^0$Bx)+ $SO_2$@150ppm. | 7 | 7 | 5 | 5 | 6 | 6 | 8 | 8 | 6 | 6 | 6.4 |
| T9 | Brewer's yeast + TSS ($24^0$Bx )+ $SO_2$ @100ppm. | 6 | 6 | 2 | 2 | 7 | 7 | 9 | 9 | 7 | 7 | 6.2 |
| T10 | Brewer's yeast +TSS ( $24^0$Bx) + $SO_2$ @150ppm | 6 | 6 | 6 | 6 | 7 | 7 | 9 | 9 | 7 | 7 | 7 |
| T11 | Brewer's yeast +TSS ( $28^0$Bx)+ $SO_2$ @100 ppm | 5 | 5 | 7 | 7 | 8 | 8 | 8 | 8 | 7 | 7 | 7 |
| T12 | T12- Brewer's yeast + TSS ($28^0$ Bx) $SO_2$ @150ppm | 6 | 6 | 3 | 3 | 8 | 8 | 10 | 10 | 6 | 6 | 6.6 |
| T13 | Local yeast + TSS ($20^0$Bx $SO_2$ @100ppm | 9 | 9 | 7 | 7 | 7 | 7 | 10 | 10 | 7 | 7 | 8 |
| T14 | Local yeast + TSS ( $20^0$Bx) $SO_2$ @150ppm. | 7 | 7 | 3 | 3 | 7 | 7 | 7 | 7 | 6 | 6 | 6 |
| T15 | Local yeast + TSS ( $24^0$ Bx)$SO_2$ @100ppm. | 8 | 8 | 6 | 6 | 8 | 8 | 4 | 4 | 6 | 6 | 6.4 |
| T16 | Local yeast + TSS (24 $^0$Bx) SO2@150ppm. | 8 | 8 | 3 | 3 | 8 | 8 | 6 | 6 | 7 | 7 | 6.4 |
| T17 | Local yeast + TSS ($28^0$Bx) $SO_2$ @100ppm. | 8 | 8 | 4 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 6.6 |
| T18 | Local yeast + TSS ($28^0$Bx) $SO_2$ @150ppm. | 8 | 8 | 5 | 5 | 9 | 9 | 9 | 9 | 6 | 6 | 7.4 |

[ P(1-10)] – Number of people who have done Organoleptic tests of different treatments of various products where P1 and P2 = 20-30 yrs, P3 and P4 =30-40 yrs, P5 and P6 = 40-50 yrs, P7and P8 = 50-60 yrs, P9 and P10 =60-70 yrs.

**Organoleptic test**

Organoleptic test like taste, aroma, sweetness, flavour, colour and overall quality were done to check the quality and acceptability of the mandarin wine. The results regarding organoleptic test have been given in Table 3.

From the organoleptic tests conducted by people from five different age group it was found that the wine from Treatment $T_1$ (Active dry yeast +TSS (20°Bx) + $SO_2$@100ppm) to Treatment $T_{18}$(Local yeast + TSS (28° Bx) $SO_2$ @150ppm) is mostly accepted for its taste, aroma, sweetness, flavour, colour and overall quality. Treatment $T_{18}$ (Local yeast + TSS (28° Bx) $SO_2$ @150ppm) was found to be good and was liked by the people of all age groups as compared to other treatments which were also satisfactory. $T_1$ (Active yeast +TSS (20°Bx) + $SO_2$@100ppm) was least liked by all the age groups.

The colour changes from yellow to dark yellow from before maturation, maturation and after maturation in $T_1$ (Active dry yeast +TSS (20°Bx) + $SO_2$@100ppm) to $T_{18}$ (Local yeast + TSS (28° Bx) $SO_2$ @150ppm). Sweetness decreased during maturation and it may be because of more alcohol formation during fermentation. Taste is better after maturation. Aroma is more alcoholic like after maturation before maturation you might smell it like mandarin juice it might also be because of alcohol content formation during maturation process and after matured. Flavours slightly like an orange but alcohol flavour masked the orange flavour later.

These above results are in line with the findings of Joshi et al. (2012); Joshi et al. (2014) and Patharkar et al. (2017). Bitterness was found in all the three types of wine. This is an indicative of proper fermentation of the fruit. In all the wines bitterness was perceivable and is on expected lines. An effective method of wine making without bitterness has been reported by Joshi et al.(1997) by using cyclodextrin and Amberlite XAD-16 to reduce it considerably and reported that debittering the juice either prior to or during fermentation improved the sensory quality of kinnow wine. Flavour of different fruit can also be added if you want more desirable wine because people like different flavour. All the wines scored more than 5.3/10 for their sensory qualities so they all are acceptable. Shelf life was longer in Treatments $T_7$ (Brewer's yeast + TSS(20°Bx)+. $SO_2$@100ppm)to $T_{12}$(Brewer's yeast + TSS (28° Bx) $SO_2$ @150ppm) followed by Treatments T1 (Active dry yeast +TSS (20°Bx) + $SO_2$@100ppm to $T_6$ (Active dry yeast + TSS ( 28°Bx) + $SO_2$@150ppm) and the shortest shelf life was in Treatments T13(Local yeast + TSS (20°Bx $SO_2$ @100ppm)to T18(Local yeast + TSS (28° Bx) $SO_2$ @150ppm). $T_{11}$ (Brewer's yeast +TSS ( 28°Bx)+ $SO_2$ @100 ppm )showed the longest shelf life and Treatment $T_{14}$(Local yeast + TSS ( 20°Bx) $SO_2$ @150ppm) has the shortest shelf life. This may be due to quality of the yeast. Marcha (local yeast) degrade more easily than other two type of yeast like Brewer's yeast and Active yeast respectively.In brief, the results indicate that there is a potential for making wine from Sikkim mandarin orange grown in Sikkim.

**CONCLUSION**

It is concluded that during maturation alcohol content of all the wine increased while TSS decreased during maturation. The fermentation of treated juice, initial sugar concentration played an important role. The fermentation of efficiency of yeast decreased with increase in the initial sugar concentration. There was a bitter taste in wine. There is a potential for making wine from Mandarin fruits grown in Sikkim since the TSS content of the juice ranges between 10-12 ºBrix. It is recommended to add cane sugar to have suitable alcohol content in the final wine to remove bitterness and also can added different flavour to have different taste. The result of the present investigation indicated that the Wine made from Mandarin having Treatment T11 (TSS

of 28°Brix and $SO_2$ 100 ppm),fermentation by Brewer's Yeast and matured for 4 months had the highest overall sensory score of 7/10 and having 10.05% ethanol content. The Sikkim mandarin wine preparation was also found profitable in this study.

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