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Changes in Chemical Composition of Raw Mango Wine

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A B S T R A C T

An investigation on "Standardization of wine making technology from mature green and ripe Alphonso mango (*Mangifera indica* L.) fruits" was conducted during the year 2020-2021 and 2021-2022 at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. In case of effect of TSS and dilution levels on chemical composition of raw Alphonso mango wine it was observed that TSS, reducing sugars, total sugars, ascorbic acid, tannins, protein and vitamin A content decreased during storage of wine and titratable acidity and alcohol content was increased at three months and then decreased at six months. pH of wine increased with increase in TSS and dilution levels except in dilution level of raw Alphonso mango. Vitamin A content decreased with increase in dilution level but showed no specific trend with TSS levels. Alcohol content increased with increase in TSS levels. In case of interactions highest titratable acidity, ascorbic acid and alcohol content was recorded by interactions T_2D_1, T_1D_1 and T_4D_1 and lowest TSS, tannin content was recorded by T_1D_5 and T_4D_5 respectively. In raw Alphonso mango wine lowest reducing sugars, total sugars, pH and highest protein and vitamin A content was recorded by T_1D_5 and T_1D_1, T_1D_5 and T_1D_1, T_3D_5 and T_2D_1, T_1D_1 and T_3D_1, T_3D_1 and T_1D_5, respectively.

Introduction

Mango (*Mangifera indica* L.) is one of the most highly priced desert fruits of the tropics. It has rich, luscious, aromatic flavour and a delicious taste in which sweetness and acidity is delightfully blended (Reddy and Reddy, 2009). Mango is known as 'King of fruits' owing to its nutritional richness, unique taste, pleasant aroma and religious and medicinal importance. Mango is believed to be originated in South East Asia, Indo-Burma region and in foot hills of the Himalayas (Mukherjee, 1951). India is largest producer of mango in the world and ranks first in area and production. The total area under mango in India is 2,350,000 hectare and production is about 21,011,000 MT with productivity of 8.7 $MTha^{-1}$, which is 35.80 per cent of total area and 21.19 per cent of the total production under fruit crops in the country (Anon, 2021). One of the largest mango growing belt in the country is Konkan region on the west coast of Maharashtra occupying 0.110 million ha productive area under mango cultivation having annual production of 3, 08,480 MT.Mango is highly perishable seasonal fruit and is processed into various products like slices, nectar, jams and pickles. Mangoes are a good source of dietary fibre (Bronce and Ona, 2015). The ripe mango is reported to have 83.46-86.70 per cent moisture, 0.82 g protein, 0.38

g fat, 14.98 g carbohydrate, 11 mg calcium, 14 mg phosphorus, 0.16 mg iron, 0.135 -1.872 Vitamin A (mg/100g beta carotene), 0.038g / 10g Riboflavin and 36 mg / 100 g ascorbic acid, 12.0-23.0 (˚Brix) TSS and 0.12-0.38 per cent acidity per 100 g edible portion of fruit. Mangoes processing is done for the following reasons: to decrease post-harvest losses and extend shelf life; create variety and hence widen the market; add value, thereby generating extra income; create new investment and employment opportunities and support local small-scale industry through the demand for equipment required for processing, preservation and packaging. An alternative way of preserving surplus mangoes could be to ferment the juice to fruit wine. This will not only increase wine variety but also add to the economy of the Nation. The country's wine sector is more than a decade old with a total production of nearly 2 crore litres annually and consumption stands at 1.5 crore litres per year. Exports barely account for 10 % of the total production. There are around 110 wineries in India including 72 in Maharashtra. While the domestic wine industry has an annual turnover of just 600 crores.

Materials and Methods

The experiment entitled "Standardization of wine making technology from mature green and ripe Alphonso mango (*Mangifera indica* L.) fruits." was conducted during the year 2020-21 and 2021-22 at Pomology Laboratory, Fruit Processing Unit of College of Horticulture, Dapoli and Fruit Beverage Research Centre of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. In this experiment, must was prepared by diluting the raw Alphonso mango fruit pulp as per the treatments i.e., 1:0, 1:0.5, 1:1, 1:1.5 and 1:2 and adjusting the T.S.S. to control, 20°Brix, 24°Brix and 28°Brix. The pH was adjusted to 3.5 as per the treatments. For extraction of pulp from mature green fruits, fruits were boiled in sufficient quantity of water till they become soft, boiled mature green (raw) fruits skin was removed by hand. Then peeled fruits were subjected to pulper and pulp was extracted. The inoculum prepared by taking white wine yeast powder (*Saccharomyces cerevisiae*) at the rate of 0.3g/kg of must in 10 times quantity of luke warm water for activation of yeast cells. After adjustment of T.S.S. and pH, must of each combination was transferred to conical flasks separately. The must was supplemented with 0.1 per cent, diammonium hydrogen phosphate (DAHP) and 30 mg/kg potassium metabisulphide (KMS). The prepared must was then used for inoculation, 2 hours after addition of KMS. Must was inoculated with yeast culture @ 0.30 g kg^{-1} and kept for fermentation at room temperature. After fermentation, the assembly was dismantled. Bentonite at the rate of 1g kg^{-1} was added, mixed well and kept for 7 days as such at cold storage (12±1°C) to separate colloidal material from wine.

Results and Discussion

Chemical composition of raw Alphonso mango wine during storage

T.S.S. (^{0}Brix)

TSS content of wine decreased from 0 (5.70 ^{0}B) to 6 months (4.83 ^{0}B) during storage. This decrease in TSS may be due to micro fermentation during storage which converts sugars into alcohol. TSS content of wine was increased with increase in T.S.S. levels from T_1 (2.94 ^{0}B) to T_4 (8.15 ^{0}B) at 0, T_1 (2.69 ^{0}B) to T_4 (7.61 ^{0}B) at 3 and T_1 (2.48 ^{0}B) to T_4 (6.94 ^{0}B) at 6 months of storage. This increase in T.S.S. may be the impact of original adjustment of T.S.S. levels of must before fermentation. The lowest TSS recorded by T_1 at 0 (2.94 ^{0}B), 3 (2.69 ^{0}B) and 6 month (2.48 ^{0}B) was significantly superior over others. In case of dilution levels TSS showed increasing trend with increase in dilution levels from D_1 to D_5. TSS increased from 5.03 ^{0}B (D_1) to 6.68 ^{0}B (D_5) at 0, 4.65 ^{0}B (D_1) to 6.29 ^{0}B (D_5) at 3 and 4.15 ^{0}B (D_1) to 5.75 ^{0}B (D_5)6 months, except D_2 at 0 and 3 months. The lowest T.S.S recorded by D_2 at '0' and 3 months was at par with D_1 at 0 (5.03 ^{0}B), 3 (4.65 ^{0}B) and 6 months.

Interaction T_1 D_5 recorded minimum TSS (2.35 ^{0}B) at 0 month and was at par with T_1 D_2 (2.5 ^{0}B) and T_1 D_4 (2.5 ^{0}B) and significantly superior over others. At 3 months T_1D_5 (2.25 ^{0}B) recorded minimum T.S.S. and was at par with T_1D_2 (2.40 ^{0}B) and T_1D_4 (2.30 ^{0}B) and significantly superior over others. At 6 months same interaction i.e. T_1D_5 recorded minimum (2.20 ^{0}B) T.S.S and was at par with T_1D_2 (2.35 ^{0}B), T_1D_3 (2.40 ^{0}B) and T_1D_4 (2.25 ^{0}B). The highest T.S.S during storage was recorded by T_4D_5 at '0' (12.05 ^{0}B), 3 (11.5 ^{0}B) and 6 (10.4 ^{0}B) months. Results of present findings are supported by Sapkal (2011) in mango wine and Pawaskar *et al.,* (2016) in kokum wine.

Reducing sugars (%)

Reducing sugars decreased from 0 (0.35 %) to 6 months (0.25 %) during storage. This decrease in reducing sugars during storage may be due to conversion of reducing

sugars into alcohol by micro fermentation. Reducing sugars were increased with increase in T.S.S. levels from T_1 (0.21 %) to T_4 (0.69 %) at 0, T_1 (0.20 %) to T_4 (0.46 %) at 3 and T_1 (0.20 %) to T_4 (0.36 %) at 6 months, except T_2 (0.20 %) at 6 months. Increase in reducing sugars may be impact of adjustment of T.S.S level in must by addition of sugar. Yeast converts specific amount of reducing sugars from different T.S.S. levels into alcohol and hence the leftover sugars showed increasing trend in wine. The lowest reducing sugar recorded by T_1 at 0 (0.21 %), at 3 (0.20 %) and T_1 (0.20 %) and T_2 (0.20 %) at 6 month was significantly superior over others except T_2 at 3 month was at par with T_1. Similar findings were reported by Sapkal (2010) in mango wine and Roodagi (2010) in pineapple wine.

In dilution levels reducing sugars showed increasing trend with increase in dilution levels from D_1 to D_5. Reducing sugar increased from 0.22 per cent (D_1) to 0.61 per cent (D_5) at 0, 0.22 per cent (D_1) to 0.38 % (D_5) at 3 and 0.21 per cent (D_1) to 0.31 per cent (D_5) at 6 months, except D_2 at 3 and 6 months storage. Increase in reducing sugars with increase in dilution levels may be due to improper fermentation in diluted juice. Results analogous to these findings were also reported by Pawar (2009) in sapota wine. In interactions of T.S.S. and dilution levels, interaction T_1 D_5 recorded minimum reducing sugars (0.19 %) at 0 and it was at par with T_1 D_1 (0.23 %), T_1 D_2 (0.21 %), T_1 D_3 (0.20 %), T_1 D_4 (0.20 %), T_2 D_1 (0.21 %), T_2 D_2 (0.21 %), T_2 D_3 (0.21 %), T_3 D_1 (0.24 %), T_4 D_1 (0.21 %) and significantly superior over others. At 3 months storage T_1D_5 (0.19 %) recorded minimum reducing sugars and at par with T_1D_1 (0.22 %), T_1D_2 (0.21 %), T_1D_3 (0.20 %), T_1D_4 (0.20 %), T_2D_1 (0.21 %), T_2D_2 (0.20 %), T_2D_3 (0.21 %), T_2D_5 (0.23 %), T_3D_5 (0.23 %) and T_4D_1 (0.21 %) and significantly superior over others. At 6 months same interaction i.e. T_1D_5 recorded minimum (0.19 %) reducing sugars and at par with all others except T_4D_3 (0.24 %), T_4D_4 (0.55 %) and T_4D_5 (0.60 %). The highest reducing sugars during storage was recorded by T_4D_5 at 6 (0.60 %) months. Minimum reducing sugars recorded by T_1D_5 during storage.

Total sugars (%)

Total sugar content of wine decreased from 0 (1.27 %) to 6 months (1.13 %) during storage.

Decrease in total sugar may be due to conversion of sugars into alcohol Even it may due to the maillard reaction resulting in non-enzymatic browning due to reaction of sugar with amino acid during storage. Total sugars increased with increase in T.S.S. levels from T_1 (1.01 %) to T_4 (1.82 %) at 0 month, T_1 (1.00 %) to T_4 (1.59 %) at 3 months and T_1 (1.00 %) to T_4 (1.26 %) at 6 months of storage. Total sugars of wine showed increasing trend as that of T.S.S. and reducing sugars. Reasons behind increase in total sugars are same as mentioned in 4.4.1 (TSS) and 4.4.2. (Reducing sugars).

The lowest total sugars recorded by T_1 at 0 (1.01 %), 3 month (1.00 %) and at 6 month (1.00 %) of storage was at par with T_2 at 3 (1.02 %) and 6 (1.02 %) and was significantly superior over others. In case of dilution levels total sugars showed increasing trend with increase in dilution levels from D_1 to D_5, irrespective of TSS levels. The total sugars increased from 1.08 per cent (D_1 & D_1) to 1.56 per cent (D_5) at 0 month, 1.06 per cent (D_1) to 1.41 per cent (D_5) at 3 months and 1.05 per cent (D_1) to 1.15 per cent (D_5) at 6 months, except D_2 at 0, 3 and 6 months. Increase in total sugars might be due to reason as mentioned in TSS levels and reducing sugars. Lowest total sugar content recorded by D_1 and D_2 at 0 month was significantly superior over others. At 3 and 6 months. D_2 recorded lowest total sugars and at 3 month at par with D_1 (1.06 %) and D_3 (1.08 %) and at 6 month again with D_1 (1.05 %) and D_3 (1.06 %) and significantly superior over others. Interactions of T.S.S. and dilution levels, T_1 D_5 recorded minimum total sugars (1.00 %) at 0 month and was at par with T_1 D_1 (1.02 %), T_1 D_2 (1.01 %), T_1 D_3 (1.01 %), T_1 D_4 (1.01 %), T_2 D_1 (1.06 %), T_2 D_2 (1.09 %), T_2 D_3 (1.11 %), T_2 D_4 (1.11 %), T_3 D_1 (1.11 %) and T_3 D_2 (1.10 %), T_4 D_1 (1.13 %) and T_4 D_2 (1.12 %). At 3 months T_1D_5 (0.98 %) recorded minimum total sugars and was at par with all others except T_3D_5 (1.17 %), T_4D_3 (1.20 %), T_4D_4 (2.16 %) and T_4D_5 (2.46 %) and at 6 months same interaction i.e. T_1D_5 recorded minimum (0.97 %) total sugars and it was at par with all others except T_3D_1 (1.08 %), T_4D_1 (1.09 %), T_4D_3 (1.14 %), T_4D_4 (1.44 %) and T_4D_5 (1.57 %) and significantly superior over others. The highest total sugars during storage was recorded by T_4D_5 at '0' (2.85 %), 3 (2.46 %) and 6 (1.57 %) months.

Tannins (%)

Tannin content of wine decreased from 0 (0.0280 %) to 6 months (0.0220 %) during storage. Decrease in tannins during storage may be due to result of oxidation and precipitation with proteins. Tannin content was decreased with increase in T.S.S. levels from T_1 (0.0300 %) to T_4 (0.0240 %) at 0, T_1 (0.0260 %) to T_4 (0.0210 %) at 3 and T_1 (0.0250 %) to T_4 (0.0200 %) at 6 months.

Table.1 Changes in TSS (0Brix) of raw Alphonso mango wine during storage

Treatment comb^{n}.	2020-21			2021-22			Pooled		
	Storage (months)			Storage (months)			Storage (months)		
	0	3	6	0	3	6	0	3	6
T_1	3.04	2.74	2.42	2.84	2.64	2.54	2.94	2.69	2.48
T_2	5.66	5.22	4.88	5.70	5.36	4.74	5.68	5.29	4.81
T_3	5.96	5.54	5.20	6.08	5.76	4.94	6.02	5.65	5.07
T_4	8.16	7.52	6.98	8.14	7.70	6.90	8.15	7.61	6.94
Average	5.71	5.26	4.87	5.69	5.37	4.78	5.70	5.31	4.83
S.E.m±	**0.07**	**0.06**	**0.05**	**0.06**	**0.05**	**0.05**	**0.06**	**0.05**	**0.05**
C.D.at 1%	**0.28**	**0.23**	**0.20**	**0.24**	**0.20**	**0.19**	**0.25**	**0.21**	**0.19**
D_1	5.02	4.60	4.05	5.03	4.70	4.25	5.03	4.65	4.15
D_2	4.83	4.42	4.22	5.05	4.78	4.30	4.94	4.60	4.26
D_3	5.38	5.10	4.6	5.38	5.15	4.38	5.38	5.13	4.49
D_4	6.53	5.80	5.5	6.43	5.98	5.45	6.48	5.89	5.48
D_5	6.78	6.35	5.98	6.58	6.23	5.53	6.68	6.29	5.75
Average	5.71	5.26	4.87	5.69	5.37	4.78	5.70	5.31	4.83
S.E.m±	**0.08**	**0.07**	**0.06**	**0.07**	**0.06**	**0.05**	**0.07**	**0.06**	**0.05**
C.D. at 1%	**0.31**	**0.28**	**0.22**	**0.27**	**0.22**	**0.21**	**0.28**	**0.24**	**0.22**
$T_1 D_1$	4.5	3.6	3.0	4.2	3.7	3.4	4.35	3.65	3.20
T_1D_2	2.4	2.3	2.2	2.6	2.5	2.5	2.5	2.40	2.35
T_1D_3	3.2	3.0	2.4	2.8	2.7	2.4	3.0	2.85	2.40
T_1D_4	2.6	2.4	2.2	2.4	2.2	2.3	2.5	2.30	2.25
T_1D_5	2.5	2.4	2.3	2.2	2.1	2.1	2.35	2.25	2.20
T_2D_1	5.1	5.0	4.2	5.2	5.0	4.4	5.15	5.00	4.30
T_2D_2	5.0	4.3	4.2	5.6	5.2	4.4	5.3	4.75	4.30
T_2D_3	6.0	5.6	5.2	6.2	5.7	5.1	6.1	5.65	5.15
T_2D_4	6.0	5.5	5.3	6.0	5.6	5.0	6.0	5.55	5.15
T_2D_5	6.2	5.7	5.5	5.5	5.3	4.8	5.85	5.50	5.15
T_3D_1	5.3	5.0	4.5	5.4	5.0	4.7	5.35	5.00	4.60
T_3D_2	5.5	5.1	5.0	5.8	5.6	5.1	5.65	5.35	5.05
T_3D_3	6.3	5.8	5.4	6.4	6.2	5.0	6.35	6.00	5.20
T_3D_4	6.3	5.9	5.5	6.3	6.1	5.0	6.30	6.00	5.25
T_3D_5	6.4	5.9	5.6	6.5	5.9	4.9	6.45	5.90	5.25
T_4D_1	5.2	4.8	4.5	5.3	5.1	4.5	5.25	4.95	4.50
T_4D_2	6.4	6.0	5.5	6.2	5.8	5.2	6.30	5.90	5.35
$T_4 D_3$	6.0	6.0	5.4	6.1	6.0	5.0	6.05	6.00	5.20
$T_4 D_4$	11.2	9.4	9.0	11.0	10.0	9.5	11.1	9.70	9.25
$T_4 D_5$	12.0	11.4	10.5	12.1	11.6	10.3	12.05	11.5	10.4
Average	5.71	5.26	4.87	5.69	5.37	4.78	5.7	5.31	4.83
S.E.m±	**0.16**	**0.13**	**0.11**	**0.13**	**0.11**	**0.11**	**0.14**	**0.12**	**0.11**
C.D. at 1%	**0.62**	**0.50**	**0.45**	**0.54**	**0.45**	**0.43**	**0.57**	**0.47**	**0.43**

Table.2 Changes in Reducing sugars (%) of raw Alphonso mango wine during storage

Treatment comb^{n}.	2020-21			2021-22			Pooled		
	Storage (months)			Storage (months)			Storage (months)		
	0	3	6	0	3	6	0	3	6
T_1	0.20	0.20	0.20	0.20	0.20	0.19	0.21	0.20	0.20
T_2	0.20	0.20	0.20	0.26	0.22	0.20	0.25	0.21	0.20
T_3	0.26	0.23	0.21	0.27	0.26	0.24	0.27	0.24	0.23
T_4	0.68	0.45	0.35	0.70	0.46	0.37	0.69	0.46	0.36
Average	0.34	0.27	0.24	0.36	0.29	0.25	0.35	0.28	0.25
S.E.m±	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
C.D.at 1%	**0.03**	**0.02**	**0.02**	**0.03**	**0.02**	**0.02**	**0.03**	**0.02**	**0.02**
D_1	0.22	0.21	0.21	0.23	0.22	0.21	0.22	0.22	0.21
D_2	0.22	0.21	0.21	0.24	0.23	0.21	0.23	0.22	0.21
D_3	0.24	0.22	0.21	0.25	0.23	0.22	0.24	0.23	0.22
D_4	0.43	0.34	0.29	0.47	0.36	0.30	0.47	0.35	0.30
D_5	0.58	0.37	0.30	0.62	0.40	0.31	0.61	0.38	0.31
Average	0.34	0.27	0.24	0.36	0.29	0.25	0.35	0.28	0.25
S.E.m±	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
C.D. at 1%	**0.03**	**0.03**	**0.02**	**0.03**	**0.02**	**0.02**	**0.03**	**0.02**	**0.02**
$T_1 D_1$	0.22	0.21	0.21	0.23	0.22	0.22	0.23	0.22	0.22
T_1D_2	0.20	0.20	0.20	0.21	0.21	0.20	0.21	0.21	0.20
T_1D_3	0.20	0.20	0.20	0.20	0.19	0.19	0.20	0.20	0.20
T_1D_4	0.20	0.20	0.20	0.20	0.20	0.19	0.20	0.20	0.20
T_1D_5	0.20	0.20	0.20	0.18	0.17	0.17	0.19	0.19	0.19
T_2D_1	0.20	0.21	0.20	0.22	0.20	0.20	0.21	0.21	0.20
T_2D_2	0.20	0.19	0.20	0.21	0.20	0.19	0.21	0.20	0.20
T_2D_3	0.20	0.20	0.20	0.21	0.21	0.20	0.21	0.21	0.20
T_2D_4	0.31	0.22	0.21	0.33	0.25	0.22	0.32	0.24	0.21
T_2D_5	0.30	0.20	0.20	0.32	0.26	0.21	0.31	0.23	0.21
T_3D_1	0.24	0.23	0.22	0.24	0.25	0.22	0.24	0.24	0.22
T_3D_2	0.24	0.23	0.22	0.26	0.25	0.23	0.25	0.24	0.23
T_3D_3	0.25	0.24	0.21	0.27	0.26	0.24	0.26	0.25	0.23
T_3D_4	0.26	0.23	0.21	0.27	0.25	0.24	0.27	0.24	0.23
T_3D_5	0.31	0.21	0.20	0.33	0.28	0.26	0.32	0.23	0.23
T_4D_1	0.20	0.20	0.20	0.22	0.21	0.21	0.21	0.21	0.21
T_4D_2	0.24	0.23	0.21	0.26	0.24	0.22	0.25	0.24	0.22
$T_4 D_3$	0.29	0.25	0.23	0.30	0.26	0.24	0.30	0.26	0.24
$T_4 D_4$	1.07	0.71	0.54	1.09	0.73	0.56	1.08	0.72	0.55
$T_4 D_5$	1.61	0.86	0.59	1.63	0.88	0.60	1.62	0.87	0.60
Average	0.35	0.27	0.24	0.36	0.29	0.25	0.35	0.28	0.25
S.E.m±	**0.02**	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**
C.D. at 1%	**0.06**	**0.05**	**0.05**	**0.06**	**0.05**	**0.04**	**0.06**	**0.05**	**0.05**

Table.3 Changes in Total sugars (%) of raw Alphonso mango wine during storage

Treatment comb^{n}.	2020-21			2021-22			Pooled		
	Storage (months)			Storage (months)			Storage (months)		
	0	3	6	0	3	6	0	3	6
T_1	1.00	1.00	0.99	1.02	1.00	1.02	1.01	1.00	1.00
T_2	1.07	1.00	1.00	1.14	1.04	1.02	1.10	1.02	1.02
T_3	1.14	1.09	1.05	1.17	1.10	1.06	1.16	1.09	1.05
T_4	1.80	1.58	1.24	1.83	1.61	1.25	1.82	1.59	1.26
Average	1.25	1.17	1.07	1.29	1.19	1.19	1.27	1.18	1.13
S.E.m±	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**
C.D.at 1%	**0.07**	**0.06**	**0.05**	**0.06**	**0.06**	**0.05**	**0.06**	**0.06**	**0.05**
D_1	1.05	1.03	1.02	1.11	1.08	1.00	1.08	1.06	1.05
D_2	1.06	1.03	1.01	1.10	1.05	1.04	1.08	1.04	1.03
D_3	1.13	1.06	1.04	1.16	1.08	1.10	1.50	1.08	1.06
D_4	1.49	1.32	1.12	1.51	1.32	1.61	1.50	1.30	1.13
D_5	1.55	1.40	1.16	1.57	1.41	1.00	1.56	1.41	1.15
Average	1.25	1.17	1.07	1.29	1.19	1.19	1.27	1.18	1.13
S.E.m±	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**	**0.02**	**0.02**	**0.01**
C.D. at 1%	**0.08**	**0.07**	**0.06**	**0.07**	**0.07**	**0.06**	**0.07**	**0.06**	**0.06**
$T_1 D_1$	1.00	1.03	1.00	1.04	1.03	1.02	1.02	1.03	1.01
T_1D_2	1.00	1.00	1.00	1.02	1.02	1.02	1.01	1.01	1.01
T_1D_3	1.00	1.00	1.00	1.02	1.00	0.99	1.01	1.00	1.00
T_1D_4	1.02	1.00	1.00	1.00	0.98	0.99	1.01	0.99	1.00
T_1D_5	1.00	0.98	0.96	1.00	0.98	0.98	1.00	0.98	0.97
T_2D_1	1.02	1.00	1.00	1.10	1.05	1.02	1.06	1.03	1.01
T_2D_2	1.05	1.02	1.00	1.12	1.04	1.03	1.09	1.03	1.02
T_2D_3	1.08	1.00	1.00	1.14	1.02	1.00	1.11	1.01	1.03
T_2D_4	1.08	1.00	1.00	1.15	1.02	1.02	1.11	1.01	1.00
T_2D_5	1.12	1.00	1.00	1.18	1.05	1.02	1.15	1.03	1.03
T_3D_1	1.08	1.05	1.03	1.13	1.12	1.10	1.11	1.09	1.08
T_3D_2	1.09	1.06	1.01	1.11	1.05	1.03	1.10	1.06	1.02
T_3D_3	1.12	1.03	1.02	1.16	1.08	1.04	1.14	1.02	1.05
T_3D_4	1.20	1.11	1.06	1.22	1.11	1.05	1.21	1.06	1.06
T_3D_5	1.22	1.18	1.12	1.23	1.15	1.07	1.22	1.17	1.02
T_4D_1	1.11	1.05	1.05	1.15	1.12	1.02	1.13	1.09	1.09
T_4D_2	1.11	1.05	1.04	1.13	1.07	1.06	1.12	1.06	1.05
$T_4 D_3$	1.31	1.19	1.13	1.33	1.21	1.15	1.32	1.20	1.14
$T_4 D_4$	2.65	2.15	1.43	2.67	2.17	1.45	2.66	2.16	1.44
$T_4 D_5$	2.84	2.45	1.56	2.85	2.47	1.58	2.85	2.46	1.57
Average	1.26	1.17	1.07	1.29	1.19	1.08	1.27	1.17	1.08
S.E.m±	**0.04**	**0.03**	**0.03**	**0.04**	**0.03**	**0.03**	**0.04**	**0.04**	**0.03**
C.D. at 1%	**0.15**	**0.14**	**0.12**	**0.14**	**0.14**	**0.11**	**0.14**	**0.14**	**0.11**

Table.4 Changes in Tannin content (%) of raw Alphonso mango wine during storage

Treatment comb^{n}.	2020-21			2021-22			Pooled		
	Storage (months)			Storage (months)			Storage (months)		
	0	3	6	0	3	6	0	3	6
T_1	0.0300	0.0250	0.0240	0.0300	0.0270	0.0260	0.0300	0.0260	0.0250
T_2	0.0250	0.0220	0.0210	0.0300	0.0240	0.0230	0.0280	0.0230	0.0220
T_3	0.0250	0.0210	0.0200	0.0270	0.0240	0.0220	0.0260	0.0230	0.0210
T_4	0.0220	0.0200	0.0200	0.0250	0.0220	0.0200	0.0240	0.0210	0.0200
Average	0.0260	0.0220	0.0210	0.0300	0.0240	0.0220	0.0280	0.0230	0.0220
S.E.m±	**0.0004**	**0.0002**	**0.0004**	**0.0003**	**0.0003**	**0.0004**	**0.0004**	**0.0004**	**0.0002**
C.D.at 1%	**0.0024**	**0.0011**	**0.0020**	**0.0013**	**0.0014**	**0.0015**	**0.0015**	**0.0015**	**0.0010**
D_1	0.0440	0.0420	0.0400	0.0500	0.0440	0.0400	0.0470	0.0430	0.0400
D_2	0.0300	0.0300	0.0240	0.0310	0.0290	0.0270	0.0310	0.0210	0.0260
D_3	0.0210	0.0200	0.0200	0.0230	0.0210	0.0190	0.0220	0.0200	0.0200
D_4	0.0200	0.0150	0.0140	0.0200	0.0170	0.0160	0.0200	0.0160	0.0150
D_5	0.0140	0.0110	0.0100	0.0200	0.0140	0.0120	0.0170	0.0130	0.0110
Average	0.0260	0.0220	0.0210	0.0300	0.0240	0.0220	0.0280	0.0230	0.0220
S.E.m±	**0.0005**	**0.0002**	**0.0004**	**0.0004**	**0.0004**	**0.0004**	**0.0004**	**0.0004**	**0.0003**
C.D. at 1%	**0.0027**	**0.0012**	**0.0016**	**0.0015**	**0.0016**	**0.0016**	**0.0017**	**0.0017**	**0.0011**
$T_1 D_1$	0.0470	0.0450	0.0400	0.0490	0.0470	0.0420	0.0480	0.0460	0.0410
T_1D_2	0.0330	0.0300	0.0290	0.0350	0.0320	0.0310	0.0340	0.0310	0.0300
T_1D_3	0.0250	0.0240	0.0220	0.0270	0.0260	0.0240	0.0260	0.0250	0.0230
T_1D_4	0.0200	0.0170	0.0180	0.0220	0.0190	0.0210	0.0210	0.0180	0.0200
T_1D_5	0.0150	0.0120	0.0120	0.0170	0.0140	0.0140	0.0160	0.0130	0.0130
T_2D_1	0.0440	0.0410	0.0390	0.0460	0.0430	0.0410	0.0450	0.0420	0.0400
T_2D_2	0.0270	0.0270	0.0260	0.0290	0.0290	0.0280	0.0280	0.0280	0.0270
T_2D_3	0.0200	0.0170	0.0160	0.0220	0.0190	0.0180	0.0210	0.0180	0.0170
T_2D_4	0.0190	0.0160	0.0140	0.0210	0.0180	0.0160	0.0200	0.0170	0.0150
T_2D_5	0.0160	0.0130	0.0100	0.0180	0.0150	0.0120	0.0170	0.0140	0.0110
T_3D_1	0.0460	0.0400	0.0390	0.0460	0.0420	0.0410	0.0460	0.0410	0.0400
T_3D_2	0.0290	0.0250	0.0240	0.0310	0.0290	0.0260	0.0300	0.0270	0.0160
T_3D_3	0.0190	0.0170	0.0140	0.0220	0.0190	0.0170	0.0210	0.0180	0.0200
T_3D_4	0.0170	0.0150	0.0120	0.0190	0.0170	0.0140	0.0180	0.0160	0.0130
T_3D_5	0.0140	0.0110	0.0100	0.0160	0.0130	0.0120	0.0150	0.0120	0.0110
T_4D_1	0.0420	0.0420	0.0370	0.0440	0.0440	0.0390	0.0430	0.0430	0.0380
T_4D_2	0.0260	0.0240	0.0190	0.0280	0.0260	0.0220	0.0270	0.0250	0.0210
$T_4 D_3$	0.0200	0.0160	0.0130	0.0220	0.0180	0.0150	0.0210	0.0170	0.0140
$T_4 D_4$	0.0140	0.0120	0.0120	0.0160	0.0140	0.0140	0.0150	0.0130	0.0130
$T_4 D_5$	0.0120	0.0100	0.0080	0.0130	0.0120	0.0100	0.0125	0.0110	0.0090
Average	0.0252	0.0227	0.0207	0.0271	0.0248	0.0228	0.0262	0.0237	0.0216
S.E.m±	**0.0010**	**0.0004**	**0.0008**	**0.0007**	**0.0008**	**0.0008**	**0.0008**	**0.0008**	**0.0006**
C.D. at 1%	**0.0053**	**0.0024**	**0.0044**	**0.0030**	**0.0031**	**0.0032**	**0.0033**	**0.0033**	**0.0022**

Table.5 Changes in Vitamin A (IU) of raw Alphonso mango wine during storage

Treatment comb^{n}.	2020-21			2021-22			Pooled		
	Storage (months)			Storage (months)			Storage (months)		
	0	3	6	0	3	6	0	3	6
T_1	4.04	4.02	3.49	4.06	4.05	3.51	4.05	4.04	3.49
T_2	4.18	4.15	3.36	4.21	4.18	3.39	4.20	4.17	3.38
T_3	4.34	4.28	3.94	4.36	4.30	3.96	4.35	4.29	3.95
T_4	4.31	4.04	3.31	4.33	4.11	3.33	4.32	4.08	3.33
Average	4.22	4.12	3.52	4.24	4.16	3.55	4.23	4.15	3.54
S.E.m±	**0.05**	**0.05**	**0.04**	**0.02**	**0.02**	**0.03**	**0.02**	**0.01**	**0.03**
C.D.at 1%	**0.20**	**0.18**	**0.17**	**0.09**	**0.06**	**0.14**	**0.09**	**0.05**	**0.12**
D_1	4.50	4.31	3.92	4.53	4.34	3.94	4.52	4.32	3.93
D_2	4.36	4.22	3.77	4.38	4.25	3.79	4.37	4.24	3.78
D_3	4.24	4.13	3.53	4.26	4.21	3.57	4.25	4.18	3.56
D_4	4.08	4.03	3.31	4.11	4.06	3.34	4.10	4.05	3.34
D_5	3.91	3.92	3.09	3.93	3.94	3.12	3.92	3.93	3.09
Average	4.22	4.12	3.52	4.24	4.16	3.55	4.23	4.15	3.54
S.E.m±	**0.06**	**0.05**	**0.05**	**0.03**	**0.02**	**0.04**	**0.02**	**0.01**	**0.03**
C.D. at 1%	**0.23**	**0.20**	**0.19**	**0.11**	**0.07**	**0.15**	**0.10**	**0.06**	**0.14**
$T_1 D_1$	4.55	4.15	3.78	4.57	4.17	3.80	4.56	4.16	3.79
T_1D_2	4.20	4.1	3.62	4.23	4.13	3.64	4.22	4.12	3.63
T_1D_3	4.04	4.07	3.47	4.05	4.09	3.49	4.05	4.08	3.48
T_1D_4	3.73	3.93	3.37	3.75	3.95	3.39	3.74	3.94	3.38
T_1D_5	3.70	3.88	3.22	3.72	3.90	3.25	3.71	3.89	3.17
T_2D_1	4.45	4.38	3.71	4.48	4.40	3.73	4.47	4.39	3.72
T_2D_2	4.31	4.24	3.53	4.33	4.26	3.55	4.32	4.25	3.54
T_2D_3	4.20	4.13	3.35	4.22	4.15	3.39	4.21	4.14	3.38
T_2D_4	4.11	4.07	3.21	4.13	4.09	3.23	4.12	4.09	3.22
T_2D_5	3.87	3.97	3.03	3.89	3.99	3.05	3.88	3.98	3.04
T_3D_1	4.56	4.50	4.32	4.58	4.52	4.34	4.57	4.51	4.33
T_3D_2	4.49	4.43	4.20	4.51	4.45	4.22	4.50	4.45	4.21
T_3D_3	4.38	4.29	3.96	4.40	4.31	3.98	4.39	4.31	3.97
T_3D_4	4.23	4.19	3.74	4.25	4.21	3.76	4.24	4.20	3.75
T_3D_5	4.05	3.99	3.48	4.07	4.01	3.51	4.06	4.00	3.50
T_4D_1	4.46	4.23	3.88	4.48	4.25	3.90	4.47	4.24	3.89
T_4D_2	4.44	4.13	3.73	4.45	4.15	3.75	4.45	4.15	3.74
$T_4 D_3$	4.36	4.05	3.37	4.36	4.30	3.40	4.36	4.18	3.39
$T_4 D_4$	4.28	3.96	2.94	4.30	3.98	2.96	4.29	3.98	3.00
$T_4 D_5$	4.02	3.85	2.64	4.05	3.87	2.66	4.04	3.86	2.65
Average	4.22	4.13	3.53	4.24	4.16	3.55	4.23	4.15	3.54
S.E.m±	**0.11**	**0.10**	**0.10**	**0.05**	**0.04**	**0.08**	**0.03**	**0.03**	**0.07**
C.D. at 1%	**0.028**	**0.030**	**0.017**	**0.009**	**0.034**	**0.025**	**0.030**	**0.034**	**0.025**

Table.6 Changes in Alcohol content (%) of raw Alphonso mango wine during storage

Treatment comb^{n}.	2020-21			2021-22			Pooled		
	Storage (months)			Storage (months)			Storage (months)		
	0	3	6	0	3	6	0	3	6
T_1	1.25	1.37	1.34	1.33	1.43	1.37	1.29	1.39	1.36
T_2	6.93	6.93	6.91	6.95	6.70	6.93	6.94	6.96	6.92
T_3	8.03	8.12	8.05	8.08	8.20	8.07	8.06	8.16	8.06
T_4	9.24	9.34	9.23	9.30	9.41	9.23	9.27	9.38	9.24
Average	6.36	6.44	6.38	6.42	6.51	6.40	6.39	6.47	6.40
S.E.m±	**0.07**	**0.08**	**0.08**	**0.03**	**0.02**	**0.04**	**0.05**	**0.05**	**0.06**
C.D.at 1%	**0.27**	**0.31**	**0.32**	**0.12**	**0.09**	**0.15**	**0.19**	**0.19**	**0.26**
D_1	7.21	7.25	7.23	7.27	7.31	7.25	7.24	7.28	7.24
D_2	6.70	6.84	6.78	6.77	6.89	6.76	6.74	6.87	6.77
D_3	6.24	6.32	6.28	6.31	6.38	6.31	6.27	6.34	6.30
D_4	5.97	6.01	5.94	6.04	6.08	5.94	6.00	6.04	5.94
D_5	5.70	5.79	5.70	5.69	5.86	5.75	5.70	5.82	5.73
Average	6.36	6.44	6.38	6.42	6.51	6.40	6.39	6.47	6.40
S.E.m±	**0.08**	**0.09**	**0.09**	**0.03**	**0.03**	**0.04**	**0.05**	**0.05**	**0.06**
C.D. at 1%	**0.31**	**0.34**	**0.35**	**0.14**	**0.10**	**0.17**	**0.21**	**0.21**	**0.25**
$T_1 D_1$	2.70	2.90	2.9	2.80	2.96	3.01	2.75	2.93	2.96
T_1D_2	1.90	2.10	2.00	1.98	2.15	1.85	1.94	2.13	1.93
T_1D_3	0.92	1.03	1.00	1.03	1.10	1.10	0.98	1.02	1.05
T_1D_4	0.51	0.55	0.56	0.60	0.62	0.60	0.56	0.59	0.58
T_1D_5	0.20	0.25	0.26	0.26	0.33	0.30	0.23	0.29	0.28
T_2D_1	7.58	7.40	7.45	7.63	7.48	7.48	7.61	7.44	7.47
T_2D_2	7.20	7.38	7.32	7.22	7.43	7.34	7.21	7.41	7.33
T_2D_3	6.71	6.69	6.76	6.77	6.75	6.78	6.74	6.72	6.77
T_2D_4	6.52	6.48	6.40	6.60	6.58	6.43	6.56	6.53	6.42
T_2D_5	6.63	6.68	6.60	6.52	6.74	6.62	6.58	6.71	6.61
T_3D_1	8.62	8.70	8.62	8.71	8.75	8.64	8.67	8.73	8.63
T_3D_2	8.13	8.21	8.20	8.19	8.27	8.22	8.16	8.24	8.21
T_3D_3	7.86	8.01	7.93	7.92	8.08	7.95	7.89	8.05	7.94
T_3D_4	8.00	8.10	8.00	8.05	8.15	8.03	8.03	8.13	8.02
T_3D_5	7.56	7.60	7.51	7.53	7.69	7.53	7.55	7.65	7.52
T_4D_1	9.93	9.99	9.93	9.95	10.05	9.88	9.94	10.02	9.91
T_4D_2	9.58	9.66	9.59	9.68	9.72	9.62	9.63	9.69	9.61
$T_4 D_3$	9.45	9.55	9.43	9.51	9.60	9.43	9.48	9.58	9.43
$T_4 D_4$	8.85	8.89	8.79	8.90	8.97	8.70	8.88	8.93	8.75
$T_4 D_5$	8.41	8.62	8.43	8.45	8.69	8.54	8.43	8.66	8.49
Average	6.36	6.44	6.38	6.42	6.51	6.40	6.39	6.47	6.40
S.E.m±	**0.15**	**0.17**	**0.18**	**0.07**	**0.05**	**0.08**	**0.10**	**0.11**	**0.13**
C.D. at 1%	**0.61**	**0.69**	**0.71**	**0.28**	**0.20**	**0.33**	**0.42**	**0.43**	**0.50**

Decrease in tannin with increase in TSS levels might be due to dilution of native tannins with addition of sugar in increasing trend to maintain different TSS levels. Lowest tannin content recorded by T_4 at 0 (0.0240 %), 3 (0.0210 %) and 6 month (0.0200 %) was significantly superior over others. These results are in agreement with the

results obtained by Pawar (2009) in sapota and More (2010) in karonda wine. In case of dilution levels tannins showed decreasing trend with increase in dilution levels from D_1 to D_5. Tannin decreased from 0.0470 (D_1) to 0.0170 per cent (D_5) at 0, 0.0430 (D_1) to 0.0130 per cent (D_5) at 3 months and 0.0400 (D_1) to 0.0110 per cent (D_5) at 6 months.

Decrease in tannins may be due to dilution of original tannin content of juice by dilution with water. Lowest tannin recorded by D_5 at 0 (0.0170 %), 3 (0.0130 %) and 6 months (0.0110 %) was significantly superior over others and highest tannin was recorded by D_1 at 0 (0.0470 %), 3 (0.0430 %) and 6 months (0.0400 %). Interaction $T_4 D_5$ recorded lowest tannin content (0.0125 %) at 0 month and it was at par with $T_3 D_5$ (0.0150 %) and $T_4 D_4$ (0.0150 %). At 3 month $T_4 D_5$ recorded lowest tannin content (0.0110 %) which was at par with T_1D_5 (0.0130 %), T_2D_5 (0.0140 %), $T_3 D_5$ (0.0120 %) and $T_4 D_4$ (0.0130 %). At 6 months$T_4 D_5$ (0.0090 %) recorded lowest tannin content and it was at par with T_2D_5 (0.0110 %) and T_3D_5 (0.0110 %). The highest tannins during storage was recorded by T_1D_1 at '0' (0.0480 %), T_4D_5 at '3' (0.0460 %) and 6 (0.0410 %) months.

Vitamin A (IU)

Vitamin A content of wine decreased from 0 (4.23 IU) to 6 months (3.54 IU) during storage. This decrease in vitamin A during storage might be due to degradation of Vitamin A during storage. The highest vitamin A content recorded by T_3 at 0 month (4.35 IU), 3 month (4.29 IU) and at 6 month (3.95 IU) of storage was at par with T_4 at 0 month (4.32 IU) and was significantly superior over others at 3 and 6 months. In case of dilution levels vitamin A showed decreasing trend with increase in dilution levels from D_1 to D_5, irrespective of TSS levels. The observed decrease in vitamin A may be due to dilution of native vitamin A of pulp with the addition of water. Similar reports were found by Pawar (2009) in sapota wine. The highest vitamin A recorded by D_1 at 0 (4.52 IU), 3 (4.32 IU) and 6 months (3.93 IU) was significantly superior over others and lowest vitamin A was recorded by D_5 at 0 (3.92 IU), 3 (3.93 IU) and 6 months (3.09 IU). In interactions of T.S.S. and dilution, T_3D_1 recorded highest vitamin A content at 0 month (4.57 IU) was at par with T_1D_1 (4.56 IU), T_2D_1 (4.47 IU), T_3D_2 (4.50 IU) and T_4D_1 (4.47 IU). At 3 month again T_3D_1 (4.51 IU) recorded highest vitamin A which was at par with T_3D_2 (4.45 IU) and at 6 months same interaction i.e. T_3D_1 (4.33 IU) recorded highest vitamin A was at par with T_3D_2 (4.21 IU) and significantly superior over others. The lowest vitamin A during storage was recorded by T_1D_5 at '0' (3.71 IU), T_4D_5 at '3' (3.86 IU) and 6 (2.65 IU) months.

Alcohol content (%)

Alcohol content of wine increased from 0 (6.39 %) to 3 months (6.47 %) and slightly decreased at 6 months (6.40 %) during storage, irrespective of TSS and dilution levels. Increase in alcohol content during first 3 months may be due to micro fermentation which converts sugars into alcohol. Whereas, decrease in alcohol from 3 to 6 months may be due to esterification which takes place between native wine acids and alcohol. Alcohol content increased with increase in T.S.S. levels from T_1 (1.29 %) to T_4 (9.27 %) at 0, T_1 (1.39 %) to T_4 (9.38 %) at 3 and T_1 (1.36 %) to T_4 (9.23 %) at 6 months of storage. This increase in alcohol content may be due to increase in T.S.S. levels of must by addition of sugars. Yeast produces pyruvic decarboxylase and alcohol dehydrogenase enzymes and these enzyme converts reducing sugars to ethanol. The highest alcohol content recorded by T_4 at 0 (9.27 %), 3 (9.38 %) and at 6 month (9.23 %) of storage. Increase in alcohol with increase in TSS level was also reported by Sapkal (2010) in mango wine and More (2010) in karonda wine. In dilution levels alcohol showed decreasing trend with increase in dilution levels from D_1 to D_5. Alcohol content decreased from D_1 (7.24 %) to D_5 (5.70 %) at 0 month, D_1 (7.28 %) to D_5 (5.82 %) at 3 months and D_1 (7.24 %) to D_5 (5.73 %) at 6 months of storage, irrespective of TSS levels. Decrease in alcohol may be due to improper fermentation and conversion of sugars to alcohol in diluted juice. The highest alcohol recorded by D_1 at 0 (7.24 %), 3 (7.28 %) and 6 months (7.24 %) was significantly superior over others and lowest alcohol was recorded by D_5 at 0 (5.70 %), 3 (5.82 %) and 6 months (5.73 %). In interactions of T.S.S. and dilution, T_4D_1 recorded highest alcohol content at 0 (9.94 %), 3 (10.02 %) and 6 (9.91 %) and was at par with T_4D_2 at 0 (9.63 %) and 3 (9.69 %) months storage. At 6 months T_4D_1 was at par with T_4D_2 (9.61 %) and T_4D_3 (9.43 %) and significantly superior over others. The lowest alcohol content during storage was recorded by T_1D_5 at '0' (0.23 %), '3' (0.29 %) and 6 (0.28 %) months.

Author Contribution

Solanke: Investigation, formal analysis, writing—original draft. A. Ankita: Validation, methodology, writing—

reviewing. C. D. Pawar:—Formal analysis, writing—review and editing. B. R. Salvi: Investigation, writing—reviewing. V. G. Salvi: Resources, investigation writing—reviewing. P. G. Borkar: Validation, formal analysis, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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