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Akash Galande
College of Horticulture, Dr. B.S.K.K.V., Dapoli, Ratnagiri, Maharashtra, India

CD Pawar
Professor, College of Horticulture, Dr. B.S.K.K.V., Dapoli, Ratnagiri, Maharashtra, India

MH Khanvilkar
Directorate of Extension Education, Dr. B.S.K.K.V., Dapoli, Ratnagiri, Maharashtra, India

JJ Kadam
Department of Plant Pathology, College of Agriculture, Dr. B.S.K.K.V., Dapoli, Ratnagiri, Maharashtra, India

Pooja Sawant
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. B.S.K.K.V., Dapoli, Ratnagiri, Maharashtra, India

Corresponding Author:
Akash Galande
College of Horticulture, Dr. B.S.K.K.V., Dapoli, Ratnagiri, Maharashtra, India

Studies on jackfruit and kokum blended wine during storage

Akash Galande, CD Pawar, MH Khanvilkar, JJ Kadam and Pooja Sawant

Abstract
The experiment was laid out in Completely Randomized Design with eight treatments and three replications by blending jackfruit and kokum natural juices. The T.S.S. of must was adjusted to 24 ^{0}Brix and pH kept natural, except treatment T_8 where pH was adjusted to 3.5. T.S.S. and pH was found to be decreased during fermentation of must. Wine recovery from must ranged between 60 and 88 per cent. Yeast count increased up to 4th day and then showed declined trend. In case of chemical composition of wine during storage, T.S.S., reducing sugars, total sugars, titratable acidity, ascorbic acid, anthocyanin, protein, tannin, pectin content decreased and pH and alcohol content of wine increased. At the end of storage lowest T.S.S. was recorded by T_5 and T_8. Treatment T_8 recorded lowest reducing sugars, total sugars and tannin while treatment T_7 had highest titratable acidity, ascorbic acid, anthocyanin and protein. Lowest pH was recorded by treatment T_7. Lowest pectin content was recorded by treatment T_1. Maximum alcohol content was recorded by treatment T_8. Treatment T_4 has highest overall sensory score. Maximum B:C ratio was recorded by treatment T_4 followed by T_2 and T_3 Hence, among different treatments under study treatment T_4 (85% jackfruit pulp + 15% kokum juice) found to be best.

Keywords: Jackfruit pulp, kokum juice, blended wine, storage

Introduction
The jackfruit tree (*Artocarpus heterophyllus* L.) belongs to the family Moraceae. According to scientist Malaysia may really be the centre of origin for jackfruit. The area under jackfruit cultivation in India is 1,87,000 Ha and total production 18,77,000 MT (Annon., 2021) [5]. The fruit is the primary economic product of the jackfruit, which is eaten both when ripe and immature. Because it feels so much like chicken when it's unripe (green). Jackfruit in brine is commonly referred to as "vegetable meat."

The Western Ghats of India are home to the tropical spice tree kokum (*Garcinia indica* Choisy). According to a baseline assessment conducted in 2010, the Konkan region grows kokum on an area of around 1000 hectares, producing roughly 4500 MT of fruit annually (Annon., 2012) [3]. Kokum fruit has cholesterol-lowering properties due to the presence of hydroxy citric acid (HCA) and garcinol. The art of blending involves creating items with a variety of colours, aromas, levels of astringency, and tastes to appeal to consumers. The kokum fruit is an excellent alternative to grapes in the wine business and may be used to make wine and liquor. Therefore, it was believed that kokum fruits should be used in the manufacture of wine. Kokum juice has a dark colour and higher levels of acidity; thus, wine can be made from kokum juice by diluting the juice and changing the pH of must in order to minimise colour and acidity and obtain a decent quantity of quality wine with low alcohol. Jackfruit is rich in sugars and has lesser calories. It has good number of antioxidants and it is rich in potassium. Wine from jackfruit can be good for health as it has good antioxidant activity and studies have reported that health from wine is due to the presence of antioxidants in them. Jackfruit and kokum production in the Konkan area has greatly increased. Jackfruit is rich source of potassium and antioxidants with low acidity level. Due to presence of natural colour and high acidity kokum is used for blending in value addition.

Materials and Methods
The experiment "Studies on jackfruit (*Artocarpus heterophyllus* L.) and kokum (*Garcinia indica* Choicy) blended wine" was laid out in Completely Randomized Design with eight treatments *viz*., T_1 - (100% jackfruit pulp), T_2 - (95% jackfruit pulp + 5% kokum juice), T_3 - (90% jackfruit pulp + 10% kokum juice), T_4 - (85% jackfruit pulp + 15% kokum juice), T_5 - (80% jackfruit pulp + 20% kokum juice), T_6 - (75% jackfruit pulp + 25% kokum juice), T_7

- (70% jackfruit pulp + 30% kokum juice), T_8 - (100% jackfruit pulp) and three replication. For this investigation fruits of jackfruit and kokum were collected from the nursery no.4 of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Jackfruit pulp was prepared from deseeded bulbs (Fig.1). For extraction of juice from kokum fruit pulp was prepared from rind by using heavy duty mixer and from this pulp juice was extracted (Fig.2).

The must was prepared by adding 0.1 per cent pectinase to the jackfruit pulp and kept for 2 hours. Then pulp was diluted with distilled water in 1:1 proportion. Then prepared juice of both the fruits was blended as per treatment details and 1 kg of blended juice was taken. The T.S.S. of blended pulp was adjusted to 24°B with the help of sugar. After adjustment of sugar, the pH of the juice was kept natural except T_8 where pH was adjusted to 3.5. The prepared must was inoculated with yeast culture after an hour by adding potassium metabisulphite (KMS) @ 30 mg per kg of juice and fermentation was allowed to continue till the must shows constant T.S.S.(Fig.3). The prepared wine was evaluated for their chemical composition and organoleptic properties after six months ageing.

Total soluble solids (T.S.S.) were determined by using Hand refractometer (Erma Japan, 0 to 32^{0}B). Reducing sugars (%), total sugars (%), titratable acidity (%) and tannin (%) content of wine were determined by using methods described by Ranganna (1997) [16]. The pH of wine was determined with the help of pH meter. (Model Systronics µ pH system 361). Ascorbic acid (mg/100 ml), pectin (%) and anthocyanin (mg/100 ml) content of wine were determined by using methods described by Ranganna (1986) [15]. The nitrogen content of wine was estimated by Kjeldahl method using Pelican kelplus equipment. Crude protein was calculated by multiplying with a factor 6.25 (A.O.A.C., 1990). The alcohol content in wine was determined by the method as reported by Natu *et al*. (1995). Sensory evaluation of wine was done by scoring wine numerically on a 20point score card under six categories of sensory quality. Statistical analysis of the wine was carried out by standard method of analysis of variance described by Panse and Sukhatme (1995) [12].

Results and Discussion

The data regarding chemical composition of must is presented in the Table 1 results were found to be non-significant with respect to T.S.S. Similar results found by Jadhav (2017) [8] while studying on preparation of jackfruit wine. In case of titratable acidity, acidity was found to have increased from T_1 (0.3%) to T_7 (1.03%). The maximum acidity observed in treatment T_7 (1.03%) which was significantly superior over other treatments. Increased acidity from T_1 (0.3%) to T_7 (1.03%) may be due to an increase in kokum juice percentage from T_1 (0%) to T_7 (30%). Similar findings were reported by Nevase (2021) [11] while studying preparation of blended wine from diluted banana and kokum juice. In case of pH results found to be significant. The pH of the must decreased from T_1 (4.84%) to T_7 (3.2%). Highest pH recorded by treatment T_1 (4.84) and lowest by T_7 (3.2) which was superior over others. While studying the preparation of blended wine from diluted banana and kokum juice, Nevase (2021) [11] found similar results.

The data regarding to the changes in T.S.S during fermentation is given in Table 2. The fermentation was found to be most active during first 4 days as indicated by a rapid fall in T.S.S. However, T.S.S. rapidly declines until the fourth day of fermentation after that, the rate of fermentation decreased and persisted until the end of fermentation at a significantly slower rate. However, the T.S.S. content remained unchanged after the 10th day. T.S.S. decreased from T_1 (11.0 ^{0}Brix) to T_5 (7.8 ^{0}Brix) towards the end of fermentation and then increased from T_5 to T_7 (8.6 ^{0}Brix). The maximum reduction in T.S.S. of must was recorded by T_5 and T_8 (7.8 ^{0}Brix). The results correspond with Nevase (2021) [11] research on blended wine made from diluted banana and kokum juice as well as Pawar (2009) [13] sapota wine.

Table 3 contains information about pH changes that occur during fermentation. The pH of the must decreased continuously as the fermentation process went on until it was finished. The pH data indicates that a decrease in must pH from T_1 (3.25) to T_7 (2.38) at the end of fermentation was caused by the initial preparation of must, which raised the percentage of kokum juice from T_1 (0) to T_7 (30%). The results correspond with Nevase (2021) [11] who studied on blended wine made from diluted banana and kokum juice.

Table 4 contains information about changes in yeast count during fermentation. The yeast count increases rapidly until the 4th day before subsequently declining until the fermentation reaches the 12th day. At the end of fermentation (12th day) highest yeast count was recorded by treatment T_1 (64 x 10^3) followed by treatment T_2 (40 x 10^3). Whereas lowest yeast count was recorded by treatment T_6 (20 x10^3) followed by T_8 (22 x 10^3) and T_7 (25 x 10^3). Kolambe (2018) [10] in soft flesh jackfruit wine and Pawaskar (2016) [14] in kokum wine reported similar results.

The data related to per cent wine recovery of jackfruit-kokum blended wine is shown in Table 5.The per cent wine recovery shows increasing trend from T_1 (60) to T_7 (88%) due to increase in kokum juice percentage from (0) to (30%) and decreased in T_8 (64%) as 100 per cent jackfruit pulp was used. The highest per cent wine recovery was observed in treatment T_7 (88%) and lowest in T_1 (60). The results for per cent wine recovery correspond with Nevase (2021) [11] in a blended wine made with banana and kokum and Jadhav (2017) [8] in jackfruit wine.

Chemical composition of wine during storage

Table 6 contains information on the chemical composition of wine at 6 months storage, in case of T.S.S. the T.S.S. content of wine decreased from T_1 (10.6 ^{0}Brix) to T_5 (7.4 ^{0}Brix) as kokum juice percentage increased from 0 to 20 per cent. From treatment T_5 to T_7 it was slightly increased i.e.7.4 ^{0}Brix (T_5) to 8.2 ^{0}Brix (T_7). Lowest T.S.S. was recorded by T_5 and T_8 (7.4 ^{0}Brix) and it was at par with T_4 (7.6 ^{0}Brix) and T_6 (7.8 ^{0}Brix) at the end of 6 months storage. Similar results reported by Nevase (2021) [11] in a blended wine made with banana and kokum diluted juice. Reducing sugars content of wine showed decreasing trend from T_1 (1.54%) to T_8 (0.35%) with increases kokum juice percentage. Lowest reducing sugar was recorded by treatment T_8 (0.35%) which was at par with treatment T_7 (0.38%) and maximum reducing sugar was recorded by treatment T_1 (1.54%) which having high T.S.S. content (10.6 ^{0}Brix) at the end of fermentation. A greater conversion of reducing sugars into alcohol could be the cause of the decrease in reducing sugar with an increase in kokum juice percentage from T_1 to T_8. Nevase (2021) [11] found similar results while studying the production of wine from diluted juice of bananas and kokum and Joshi *et al.* (2015) [9] while studying quality of blended wine prepared from white and red varieties of grape (*Vitis vinifera* L.).Total sugar content of

wine showed decreasing trend from T_1 (1.79%) to T_8 (0.51%) with increases kokum juice percentage. Lowest total sugar content was recorded by treatment T_8 (0.51%) which was significantly superior over other treatments. The maximum total sugar was recorded by treatment T_1 (1.79%) which having high T.S.S. content (10.6 ^{0}Brix) at the end of 6 months storage. Nevase (2021) [11] found similar results while studying the production of wine from diluted juice of bananas and kokum and Flory *et al.* (2022) [6] while studying influence of maturation on the nutrient retention and sensory evaluation of fermented beverages developed from blood fruit and aonla. At six months of storage, the titratable acidity of blended wine increased from T_1 (0.42%) to T_7 (0.78%) and then decreased in T_8 (0.67%). This increase in acidity may be impact of increasing kokum juice percentage from T_1 (0) to T_7 (30%). The significantly highest titratable acidity was recorded by treatment T_7 (0.78%) which was significantly superior over other treatments. Lowest titratable acidity was recorded by treatment T_1 (0.42%). Joshi *et al.* (2015) [9] found similar range of acidity while studying quality of blended wine prepared from white and red varieties of grape (*Vitis vinifera* L.). At six months of storage the pH of wine decreased from T_1 (3.41) to T_7 (2.48) and it was increased in T_8 (3.20). Lowest pH was recorded by treatment T_7 (2.48) which was at par with treatment T_6 (2.68) and significantly superior over all others treatments. Highest pH was recorded by treatment T_1 (3.41). Production of hydrogen ions due to breakdown of the acids may have led to increase in the pH of wine. Sharma *et al*. (2003) [17] found similar results while studying the effect of maturation on the physico-chemical and sensory quality of strawberry wine throughout the storage period of nine months. Ascorbic acid content of wine increased from T_1 (2.72 mg/100 ml) to T_7 (11.22 mg/100 ml) with increase in kokum juice percentage from T_1 (0) to T_7 (30%) and then slightly decreased in T_8 (2.80 mg/100 ml) where 100 per cent jackfruit pulp was used. Highest ascorbic acid content was recorded by treatment T_7 (11.22 mg/100 ml) which was significantly superior than all others treatments. Lowest ascorbic acid content was recorded by treatment T_1 (2.72 mg/100 ml). Increase in ascorbic acid from T_1 to T_7 may be due to increase in kokum juice percentage from T_1 to T_7. Similar findings were reported by Gnoumou *et al*. (2022) [7] while studying the stability of mixed cashew and papaya wine produced with palm wine sediment and Flory *et al.* (2022) [6] while studying influence of maturation on the nutrient retention and sensory evaluation of fermented beverages developed from blood fruit and aonla.

Anthocyanin content of wine increased from T_1 (6.80 mg/100 ml) to T_7 (112.10 mg/100 ml) with an increase in kokum juice percentage from T_1 (0) to T_7 (30%) in blended must, and subsequently decreased at T_8 (6.45 mg/100 ml) where 100 per cent jackfruit pulp was present. The highest anthocyanin content was recorded by treatment T_7 (112.10 mg/100 ml) which was significantly superior over other treatments. Treatment T_8 (6.45 mg/100 ml) had the lowest anthocyanin content. Similar results were reported by Sharma *et al*. (2003) [17] while studying the effect of maturation on the physico-chemical and sensory quality of strawberry wine throughout the storage period of nine months. Protein content of wine increased from T_1 (0.25%) to T_7 (0.48%) may be impact of increase in kokum juice from 0 to 30 per cent and subsequently decreased at T_8 (0.23%) where 100 per cent jackfruit pulp was used. Highest protein content was recorded by treatment T_7 (0.48%) which was significantly superior over all others treatments. Lowest protein content was recorded by treatment T_8 (0.23%). Macromolecule proteins undergo degradation during fermentation to produce free amino acids and short peptides. Oxidation also causes side chain modification, polymerization, and peptide chain cleavage in amino acids. Similar findings were reported by Pawar (2009) [13] while studying on wine making technology in sapota. Tannin content of wine increased from T_1 (0.20%) to T_7 (0.33%) may be impact of increase in kokum juice from 0 to 30 per cent and subsequently decreased in T_8 (0.19%) where 100 per cent jackfruit pulp was used. Lowest tannin content was recorded by treatment T_8 (0.19%) which was at par with treatment T_1 (0.20%) and T_2 (0.22%). Highest tannin content in wine was recorded by treatment T_7 (0.33%). Similar findings were reported by Pawar (2009) [13] while studying on wine making technology in sapota. Pectin content of wine increased from T_1 (0.13%) to T_7 (0.41%) and subsequently decreased in T_8 (0.14%). Lowest pectin content was recorded by treatment T_1 (0.13%) which was at par T_2 (0.15%) and T_8 (0.14%) and significantly superior over all others treatments. Highest pectin content was recorded by treatment T_7 (0.41%). Increase in pectin from T_1 to T_7 may be impact of increase in kokum juice from 0 to 30 per cent. Similar results were reported by Sethy *et al*. (2018) [18] while studying effect of storage on physico-chemical and sensory qualities of commercial fruit beverages. Alcohol content of wine increased from T_1 (7.42%) to T_5 (14.24%) and thereafter decreased from T_5 (14.24%) to T_7 (12.50%) and again increased in T_8 (14.25%). The present trend of alcohol may be impact of fermentation. Better the fermentation lower will be the T.S.S. and higher will be alcohol level. Maximum alcohol content was recorded by treatment T_8 (14.25%) which was at par with T_5 (14.24%) and T_6 (13.90%). Lowest alcohol content was recorded by treatment T_1 (7.42%). Similar results were reported by Sharma *et al*. (2003) [17] while studying the effect of maturation on the physico-chemical and sensory quality of strawberry wine throughout the storage period of nine months and Joshi *et al.* (2015) [9] while studying quality of blended wine prepared from white and red varieties of grape (*Vitis vinifera* L.).

Sensory evaluation of jackfruit - kokum blended wine during storage

Table 7 displays information on the sensory evaluation of the blended wine made with jackfruit and kokum. A panel of 10 judges used a 20-point scorecard to assess the wine prepared from blended juice of jackfruit and kokum in terms of its sensory qualities. At the end of storage (6 months) treatment T_4 got maximum score for colour and appearance, taste and astringency (15), for body treatment T_5 got maximum score (15), in case of score for aroma treatment T_8 got maximum score (14). For overall acceptability and overall quality treatment T_4 got maximum score (15) out of 20 which comes under standard wine.

Cost of production of wine prepared by blending jackfruit and kokum natural juice

The production cost of 180 ml of blended wine with jackfruit and kokum was highest in T_1 (Rs. 18.35) and lowest in T_2 (Rs. 16.02). Highest net profit (Rs. 63.14) was in treatment T_4 and the lowest (Rs.42.61) was in treatment T_7. In case of benefit cost ratio treatment T_4 recorded the highest (4.74), followed by T_2 (4.37) and T_3 (4.25), while treatment T_7 recorded the minimum (3.45).

Table 1: Chemical composition of must prepared by blending jackfruit and kokum juice

Treatments			T.S.S. (^{0}Brix)	Titratable acidity (%)	pH
	J (%)	K (%)			
T_1	100	00	24.2	0.30	4.84
T_2	95	05	24.0	0.32	4.26
T_3	90	10	24.0	0.48	4.00
T_4	85	15	24.2	0.62	3.76
T_5	80	20	24.0	0.78	3.50
T_6	75	25	24.2	0.88	3.35
T_7	70	30	24.0	1.03	3.20
T_8			24.2	0.96	3.50
Mean			24.10	0.67	3.80
S. Em. (±)			0.04	0.007	0.011
C.D. at 1%			N.S.	0.029	0.047

Table 2: Changes in T.S.S. (^{0}Brix) during fermentation of the must

Treatments	0 Day	2nd Day	4th Day	6th Day	8th Day	10th Day	12th Day
T_1	24.2	18.6	11.8	11.2	11.2	11.0	11.0
T_2	24.0	16.0	11.0	9.6	9.6	9.2	9.2
T_3	24.0	17.2	9.6	9.2	8.8	8.6	8.6
T_4	24.2	16.4	10.0	8.8	8.4	8.0	8.0
T_5	24.0	16.4	9.2	8.2	8.0	7.8	7.8
T_6	24.2	16.2	11.2	9.0	8.4	8.2	8.2
T_7	24.0	18.0	9.0	8.8	8.6	8.6	8.6
T_8	24.2	22.0	8.8	8.4	8.2	7.8	7.8
Mean	24.17	17.60	10.07	9.15	8.90	8.65	8.65

Table 3. Change in pH during fermentation of the must

Treatments	0 Day	2nd Day	4th Day	6th Day	8th Day	10th Day	12th Day
T_1	4.84	3.96	3.80	3.70	3.50	3.43	3.25
T_2	4.26	3.80	3.63	3.50	3.46	3.33	3.16
T_3	4.00	3.76	3.53	3.49	3.30	3.10	3.10
T_4	3.76	3.60	3.52	3.40	3.30	3.28	2.88
T_5	3.50	3.36	3.20	3.14	3.10	2.90	2.71
T_6	3.35	3.20	3.18	3.10	3.10	3.06	2.53
T_7	3.20	3.13	2.79	2.66	2.54	2.45	2.38
T_8	3.50	3.40	3.30	3.28	3.16	3.10	3.14
Mean	3.79	3.50	3.36	3.28	3.18	3.08	2.80

Table 4: Changes in yeast count during fermentation of the must

Treatments	Colony count in number × 10^3			
	0 day	4th Day	8th day	12th day
T_1	0	1760	480	64
T_2	0	1880	540	40
T_3	0	1560	320	31
T_4	0	1430	300	28
T_5	0	1260	280	26
T_6	0	860	240	20
T_7	0	946	220	25
T_8	0	940	310	22
Mean	0	1329.5	336.25	32

Table 5: Per cent wine recovery from blended must of jackfruit and kokum

Treatments	Wine recovery (%)							
	T_1 (100:0)	T_2 (95:5)	T_3 (90:10)	T_4 (85:15)	T_5 (80:20)	T_6 (75:25)	T_7 (70:30)	T_8 Control
Mean	60	72	76	79	80	84	88	64
S. Em. (±)	**0.957**							
C.D. at 1%	**3.95**							

Table 6: Chemical composition of jackfruit and kokum blended wine (T.S.S., reducing sugars, total sugars, titratable acidity and pH, ascorbic acid, anthocyanin, total protein, tannin, pectin and alcohol) during 6 months of storage

Treatments	T.S.S. (^{0}Brix)	Reducing sugars (%)	Total sugars (%)	Titratable acidity (%)	pH	Ascorbic acid (mg/100 ml)	Anthocyanin (mg/100 ml)	Protein (%)	Tannin (%)	Pectin (%)	Alcohol (%)
T_1	10.6	1.54	1.79	0.42	3.41	2.72	6.80	0.25	0.20	0.13	7.42
T_2	8.8	1.29	1.6	0.47	3.26	4.12	47.26	0.28	0.22	0.15	9.21
T_3	8.0	1.04	1.39	0.52	3.20	5.15	58.02	0.32	0.24	0.22	11.70
T_4	7.6	0.74	1.16	0.55	3.00	5.37	83.92	0.34	0.26	0.27	13.00
T_5	7.4	0.60	0.95	0.58	2.84	7.26	87.80	0.40	0.27	0.30	14.24
T_6	7.8	0.47	0.85	0.67	2.68	9.55	96.73	0.44	0.31	0.35	13.90
T_7	8.2	0.38	0.69	0.78	2.48	11.22	112.10	0.48	0.33	0.41	12.50
T_8 (Control)	7.4	0.35	0.51	0.67	3.20	2.80	6.45	0.23	0.19	0.14	14.25
Mean	8.24	0.80	1.11	0.58	3.00	6.02	62.38	0.34	0.25	0.24	12.02
S. Em. (±)	0.13	0.02	0.02	0.01	0.04	0.06	0.48	0.01	0.01	0.008	0.12
C.D. at 1%	0.56	0.09	0.08	0.05	0.19	0.25	1.99	0.04	0.04	0.034	0.50

Table 7: Sensory evaluation of jackfruit and kokum blended wine

Treatments	Colour & Appearance	Body	Aroma	Taste	Astringency	Overall acceptability	Overall quality (Avg. score)
T_1	11	10	13	12	12	12	12
T_2	12	11	13	14	14	13	13
T_3	13	11	13	13	14	13	13
T_4	15	14	13	15	15	15	15
T_5	14	15	13	12	13	12	13
T_6	12	12	11	10	11	12	11
T_7	12	11	12	11	12	11	11
T_8 (Control)	12	13	14	13	12	13	13
Mean	13	12	13	13	13	13	13
Grape wine	16	14	15	15	15	13	15

Table 8: Cost of production of wine prepared from 1kg must prepared from jackfruit and kokum blended juices

Treatments	Cost of production 1kg of wine (Rs)	Cost of production 180 ml of wine (Rs)	Sale price / 180 ml bottle (Rs)	B:C ratio
T_1	61.11	18.35	65	3.54
T_2	64.11	16.02	70	4.37
T_3	69.51	16.47	70	4.25
T_4	73.83	16.86	80	4.74
T_5	75.25	16.95	70	4.13
T_6	80.03	17.17	60	3.49
T_7	84.88	17.39	60	3.45
T_8	62.65	17.65	70	3.97

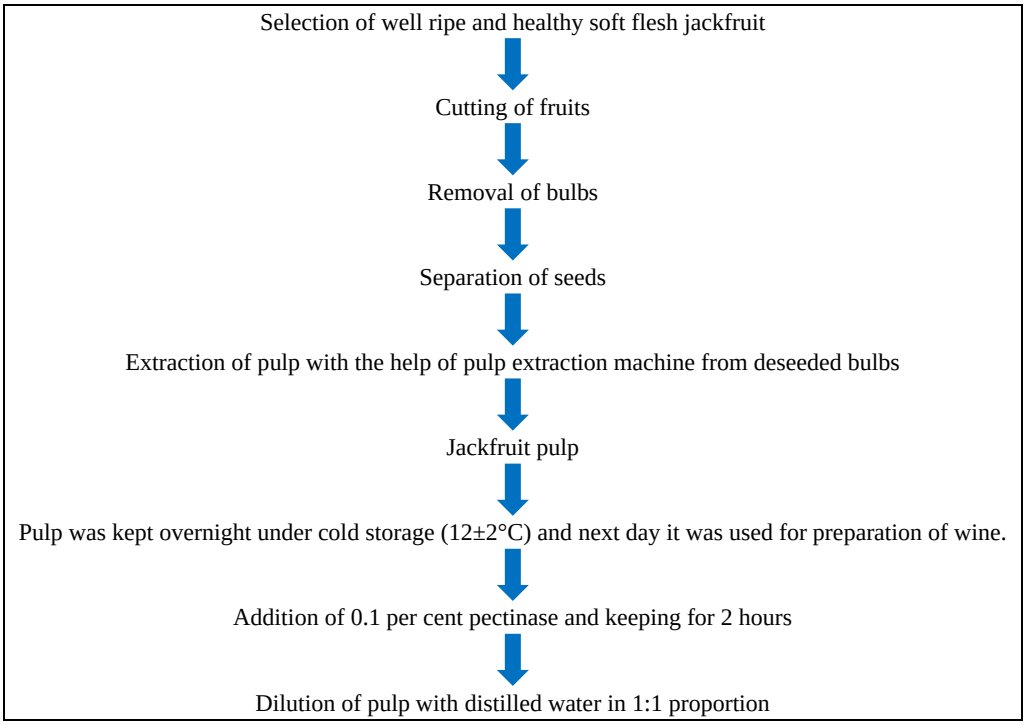

Fig 1: Preparation of soft flesh jackfruit pulp for wine

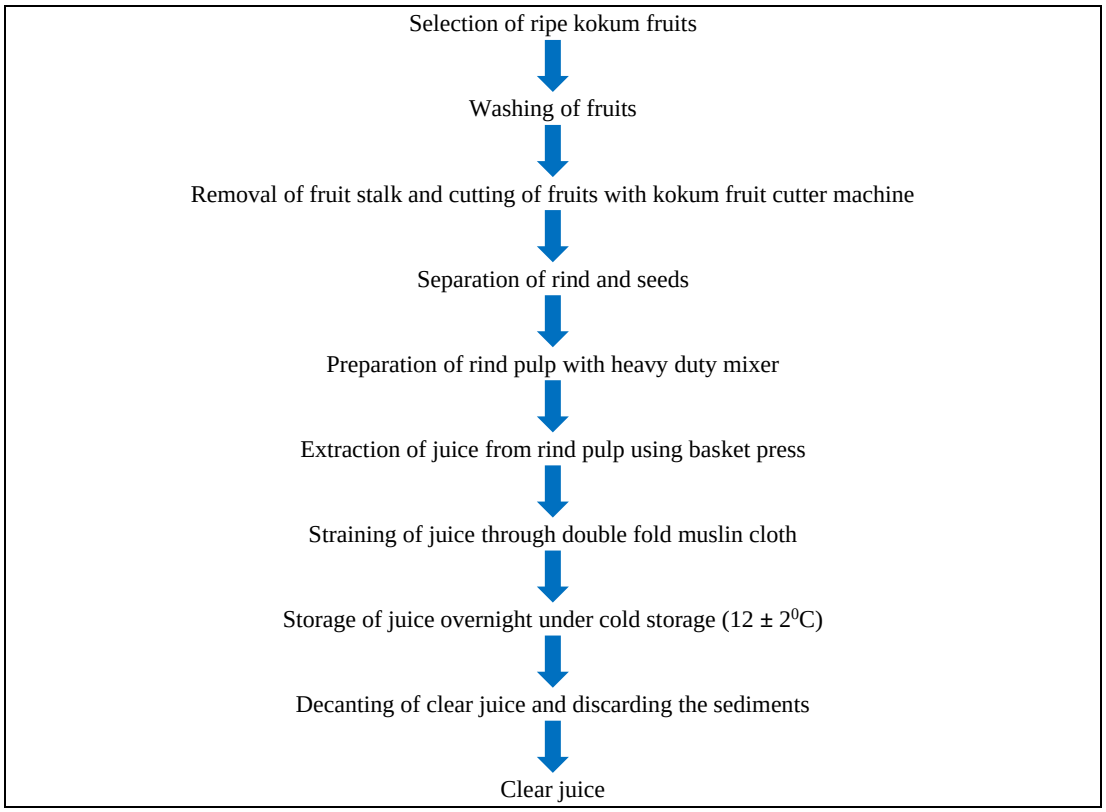

Fig 2: Extraction of juice from kokum fruits

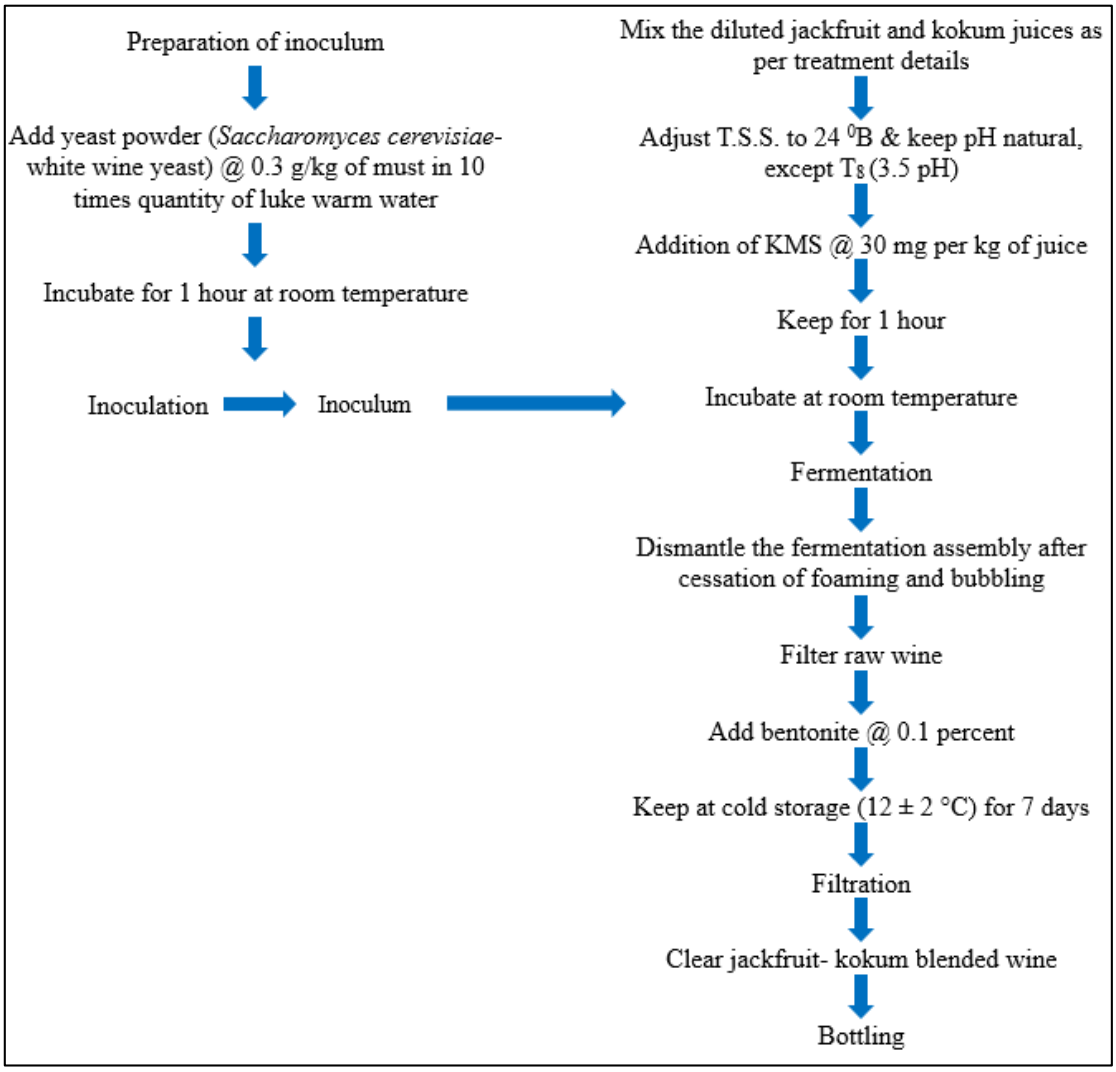

Fig 3: Preparation of jackfruit -kokum blended wine

Conclusion

From this research it can be concluded that best quality standard wine could be prepared from treatment T_4 (85% jackfruit + 15% kokum juice) which is having maximum overall quality score (15) and maximum B:C ratio (4.74).

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