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INFLUENCE OF BANANA (*Musa paradisiaca* L.) AND KOKUM (*Garcinia indica* Choisy) JUICE BLENDING ON MUST COMPOSITION AND FERMENTATION CHARACTERISTICS OF WINE

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ABSTRACT

An investigation entitled “Influence of Banana (*Musa paradisiaca* L.) and Kokum (*Garcinia indica* Choisy) Juice Blending on Must Composition and Fermentation Characteristics of Wine” was conducted during 2020–21 at the Pomology Laboratory, Fruit Processing Unit, College of Horticulture, Dapoli and Fruit Beverage Research Centre, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri. The objective of the study was to evaluate the effect of blending banana and kokum juice on the chemical composition of must and its fermentation characteristics. The experiment was conducted in a Completely Randomized Design (CRD) with seven treatments comprising different proportions of banana and kokum juice, namely T₁ (100:0), T₂ (95:5), T₃ (90:10), T₄ (85:15), T₅ (80:20), T₆ (75:25) and T₇ (70:30). The prepared must was inoculated with *Saccharomyces cerevisiae* var. bayanus and fermented under ambient conditions. The results indicated significant differences among treatments with respect to chemical composition and fermentation behaviour of the must. The highest T.S.S. (22.00°Brix) and pH (4.33) were recorded in T₁, whereas the highest titratable acidity (1.58%) and lowest pH (2.89) were observed in T₇. Increasing the proportion of kokum juice resulted in a decrease in T.S.S. and pH, while acidity increased significantly. During fermentation, T.S.S. decreased continuously in all treatments due to the conversion of sugars into alcohol. The maximum reduction in T.S.S. was recorded in T₄, indicating favourable fermentation conditions. The pH of the fermenting must decreased gradually, while yeast population increased up to the third day and declined thereafter due to alcohol accumulation. Fermentation was completed within 13 to 19 days depending on the treatment. The highest wine recovery (70.13%) was recorded in T₇, while the lowest (62.07%) was observed in T₁. The study concluded that blending banana juice with kokum juice favourably influenced the chemical composition of must, improved fermentation characteristics and enhanced wine recovery, resulting in the production of acceptable quality blended wine.

Key words: Banana, Kokum, Blended wine, Must, Fermentation, Yeast count, Wine recovery.

Introduction

Banana (*Musa paradisiaca* L.) is one of the most important fruit crops cultivated in tropical and subtropical regions of the world. India is the largest producer of banana globally, with a production of about 37.8 million tonnes during 2023–24 from nearly 1.0 million hectares, contributing significantly to the country's fruit economy

(MoA & FW, 2025). Major banana-growing states include Maharashtra, Tamil Nadu, Gujarat, Andhra Pradesh and Karnataka. Banana is a highly productive crop owing to its year-round availability and high yield potential. The fruit is rich in carbohydrates, dietary fibre, potassium, calcium, phosphorus, vitamin B6, vitamin C and β -carotene, making it an excellent source of nutrition.

Banana is also reported to possess several health benefits and is traditionally used in the management of digestive disorders, constipation, anaemia, kidney ailments and cardiovascular diseases (Joshi *et al.*, 2012).

Despite its high production, banana suffers substantial post-harvest losses due to its highly perishable nature, improper handling, inadequate storage facilities and inefficient marketing systems. Post-harvest losses in banana have been reported to range from 15–30%, leading to considerable economic losses for growers and traders (Davara and Patel, 2009). Processing of surplus fruits into value-added products such as wine can help reduce these losses while enhancing farmers' income.

Kokum (*Garcinia indica* Choisy), belonging to the family Clusiaceae, is an indigenous fruit tree of the Western Ghats of India. It is mainly cultivated in Maharashtra, Goa, Karnataka and Gujarat. The fruit is valued for its attractive purple-red colour, pleasant acidity and high content of bioactive compounds such as hydroxycitric acid, garcinol, anthocyanins and polyphenols. Kokum exhibits antioxidant, anti-inflammatory, anti-obesity, cardioprotective and antimicrobial properties and has long been used in traditional Ayurvedic medicine for the treatment of digestive disorders, diarrhoea, sunstroke and skin ailments (Swami *et al.*, 2014; Lim *et al.*, 2021). The fruit is commonly processed into squash, syrup, ready-to-serve beverages, pickle, amsul and kokum butter. However, a substantial quantity of fruits remains underutilized due to limited processing and market opportunities.

Blending is an important technique in beverage production that combines the desirable characteristics of two or more fruits to improve flavour, aroma, colour, nutritional quality and consumer acceptability. Banana provides fermentable sugars, body and mouthfeel to wine, whereas kokum contributes natural acidity, attractive colour, antioxidants and unique flavour. Therefore, blending banana and kokum can result in a nutritionally enriched and organoleptically superior wine with enhanced functional properties.

Development of banana–kokum blended wine offers an effective strategy for the utilization of surplus and underutilized fruits, reduction of post-harvest losses and diversification of fruit-based products. Such value addition can create new market opportunities, generate rural employment and improve profitability for farmers, thereby contributing to sustainable horticultural development.

Material and Methods

The experiment entitled “Standardization of blended wine from banana (*Musa accuminata*) and kokum

(*Garcinia indica* Choisy)” was carried out in the year 2020-2021 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, the must was prepared by blending banana and kokum natural juice as per treatments i.e., T₁- (100% banana juice), T₂- (95% banana juice + 5% kokum juice), T₃- (90% banana juice+ 10% kokum juice), T₄- (85% banana juice+ 15% kokum juice), T₅- (80% banana juice+ 20% kokum juice), T₆- (75% banana juice+ 25% kokum juice) and T₇- (70% banana juice+ 30% kokum juice) and three replications in completely randomized design.

For this study, Banana unripe fruits (Grand naine) were purchased from Central Experimental Station, Wakavali. Selected fruits were treated with 500 ppm Ethrel solution for 5 minutes and kept for ripening for seven days at ambient temperature. After ripening fruits were used for further study. Well ripened, healthy and disease free banana fruits were selected for extraction of fine pulp. The peel of the fruit was removed and pulp was prepared by using heavy duty mixer. Then pulp was heated at 40°C temperature for 5 minutes. After cooling pectinase enzyme was added into the pulp, 1gm per kg of pulp. Then pulp was kept overnight under cold storage (12±2°C). The fine pulp was used for wine preparation (Fig. 1). Well ripe, sound, healthy and disease free kokum fruits were washed thoroughly with running tap water and rinsed with distill water. Fruit stalks were removed and then fruits were cut with kokum cutter machine and rind and seeds are separated. Pulp was prepared from rind by using heavy duty mixer. Then the juice was extracted from kokum pulp by using basket press and

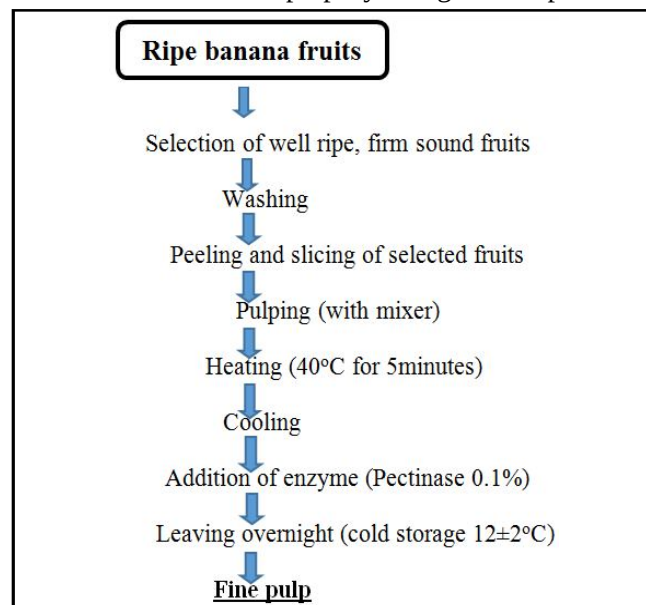
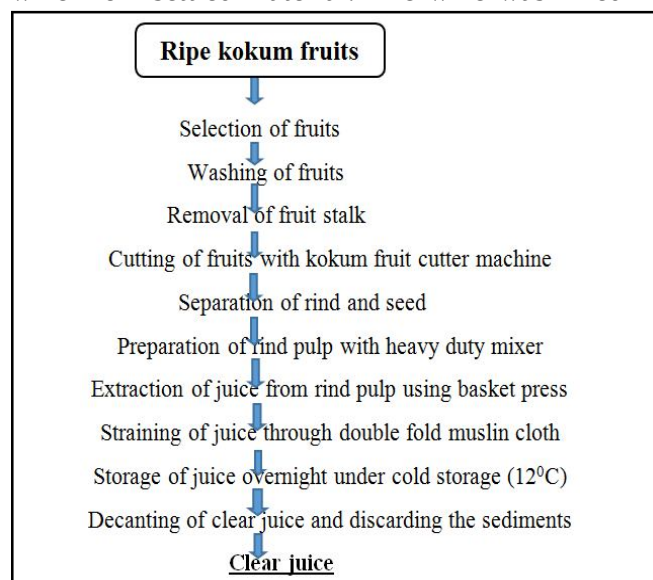


Fig. 1: Preparation of fine pulp from banana fruits.

Table 1: Chemical composition of must prepared by blending banana and kokum natural juice.

Treatments	T.S.S. (°Brix)	Titrateable acidity (%)	pH
T ₁	22.0	0.37	4.33
T ₂	21.33	0.55	4.00
T ₃	20.97	0.72	3.65
T ₄	20.07	0.99	3.40
T ₅	19.83	1.21	3.18
T ₆	19.00	1.38	3.01
T ₇	18.73	1.58	2.89
S.E.m. ±	0.10	0.02	0.05
C.D at 1%	0.41	0.09	0.21

then kept overnight under cold storage ($12\pm 2^\circ\text{C}$). The clear juice was obtained by decanting and used for preparation of wine (Fig. 2). The must was prepared by blending the banana and kokum natural juice as per treatment details. 1kg of blended juice was taken for each treatment. The experiment was conducted with seven treatments (T₁ to T₇) and three replications (R₁ to R₃). As the wine was prepared from natural juice, the T.S.S. and pH were not adjusted. The prepared must was inoculated with red wine yeast powder (*Saccharomyces cerevisiae* var. bayanus) at the rate of 0.3 g/kg of must in 10 times quantity of lukewarm water for activation of yeast cells. Must was inoculated with yeast culture @ 0.30 g kg^{-1} and kept for fermentation at room temperature and fermentation was allowed to continue till the must showed constant T.S.S. The assembly was dismantled after end of fermentation. The raw wine was filtered through double folded muslin cloth. The filtered wine is then pasteurized at 80°C for 10 minutes and kept for 7 days as such at cold storage ($12\pm 2^\circ\text{C}$) to separate colloidal material from wine. Siphoning was done to obtain clear wine from settled material. The wine was filled in

**Fig. 2:** Extraction of juice from kokum fruits.

sterilized bottles, sealed and stored at cold storage ($12\pm 2^\circ\text{C}$) until used for chemical analysis and sensory evaluation (Fig. 3).

Total soluble solids (T.S.S.) were determined with the help of Hand refractometer (Erma Japan, 0 to 32°Brix) and value was corrected at 20°C with the help of temperature correction chart (A.O.A.C., 1975). The pH of the wine was determined with the help of pH meter. (Model Systronics μpH system 361). The titrateable acidity (%) was estimated as per the methods suggested by Ranganna (1977).

Results and Discussion

Chemical composition of must prepared by blending natural juice of banana and kokum

The data regarding chemical composition of must is presented in Table 1. Results are found to be significant with respect to T.S.S., Titrateable acidity and pH of must. In case of T.S.S., significantly highest T.S.S. (22°Brix) was recorded by treatment T₁ (100% banana juice) and lowest (18.73°Brix) by T₇ (70% banana and 30% kokum juice). The T.S.S. of must was found to be decreased from T₁ to T₇. These results are in agreement with results observed by Deshpande *et al.*, (2020) in blended wine of grape, guava and noni juice. In case of titrateable acidity, the acidity was found to be increased from T₁ (0.37%)

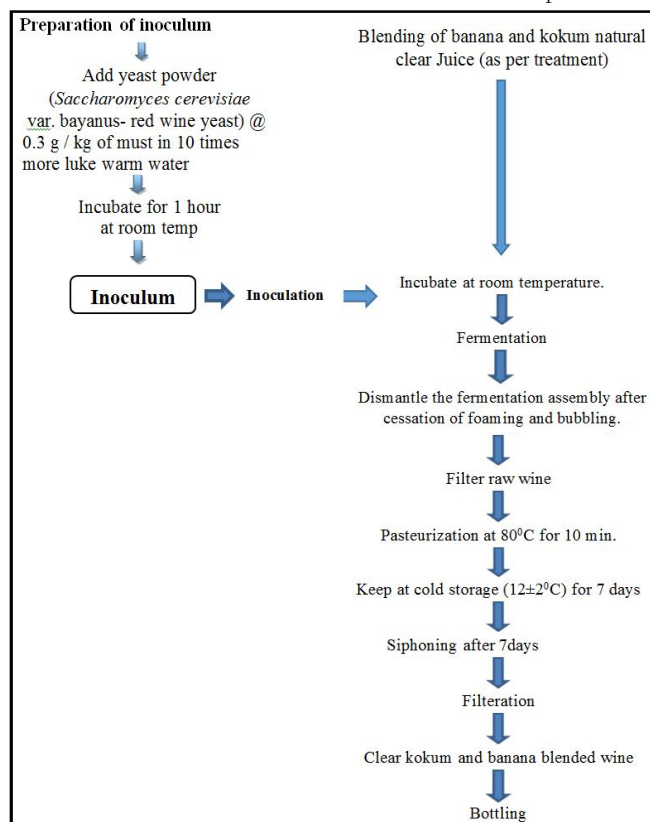
**Fig. 3:** Preparation of wine from banana and kokum natural juice

Table 2: Changes in T.S.S. (°Brix) during fermentation of the must.

Treatments	'0' day	1 st day	3 rd day	5 th day	7 th day	9 th day	11 th day	13 th day	15 th day	17 th day	19 th day
T ₁	22.00	19.33	13.33	10.60	9.96	8.63	8.62	-	-	-	-
T ₂	21.33	19.10	13.26	9.58	7.90	7.73	7.50	7.50	-	-	-
T ₃	20.96	18.93	12.86	9.01	7.16	7.12	7.10	7.10	-	-	-
T ₄	20.06	18.06	11.06	8.25	7.43	7.26	6.84	6.64	-	-	-
T ₅	19.83	18.13	16.04	9.60	9.36	8.73	8.66	7.90	7.90	-	-
T ₆	19.00	18.00	17.40	13.16	12.17	11.22	10.90	10.76	10.64	9.50	9.50
T ₇	18.75	17.06	17.04	16.40	16.22	14.48	14.23	11.24	10.29	10.12	10.12

to T₇ (1.58%). The highest acidity recorded by T₇ was significantly superior over others. The increase in acidity from T₁ (100% banana juice) to T₇ (70% banana + 30% kokum juice) may be due to increase in kokum juice percentage from T₁ (0.0%) to T₇ (30%). These results are in agreement with results observed by Deshpande *et al.*, (2020) in blended wine of grape, guava and noni juice. In case of pH, results are found to be significant. Lowest (2.89) pH was recorded by T₇ (70% banana + 30% kokum juice) and it was on par with T₆ (3.01) and significantly superior over others. Highest (4.33) pH was recorded by T₁ (100% banana juice). The pH was found to be decreased from T₁ (4.33) to T₇ (2.89). Result analogous to present finding was also reported by Sadgir (2015) while studying preparation of wine by blending of cashew apple and pineapple juice.

Changes in T.S.S. (°Brix) during fermentation of banana and kokum blended must

The data pertaining to the changes in T.S.S. during fermentation of must are presented in Table 2. It is seen from Table that T.S.S. content of must was decreased continuously till the end of fermentation. However, it decreased sharply in the initial period of fermentation. There was sharp decrease in T.S.S. upto 5th day of inoculation and later on, the rate of fermentation was found to be declined but continued at a much slower rate till the end of fermentation.

From the data of T.S.S. at the end of fermentation it was observed that, the T.S.S. was decreased from T₁ (8.62°Brix) to T₄ (6.64°Brix) and again increased from T₄ to T₇ (10.12°Brix). The maximum reduction in T.S.S. of must was recorded by T₄ followed by T₃ (7.10°Brix).

Table 3: Changes in pH during fermentation of the must.

Treatments	'0' day	1 st day	3 rd day	5 th day	7 th day	9 th day	11 th day	13 th day	15 th day	17 th day	19 th day
T ₁	4.32	3.95	3.94	3.92	3.87	3.86	3.85	-	-	-	-
T ₂	4.00	3.93	3.91	3.90	3.87	3.82	3.80	3.81	-	-	-
T ₃	3.65	3.70	3.80	3.87	3.87	3.83	3.81	3.80	-	-	-
T ₄	3.39	3.44	3.55	3.58	3.58	3.55	3.53	3.50	-	-	-
T ₅	3.17	3.25	3.30	3.37	3.35	3.33	3.20	3.18	3.15	-	-
T ₆	3.01	3.08	3.09	3.12	3.12	3.19	3.18	3.17	3.10	3.00	2.92
T ₇	2.88	2.94	2.98	2.98	2.94	2.89	2.86	2.84	2.82	2.80	2.78

This may be due to congenial condition for fermentation (especially pH around 3.5) was available at '0' day in must (Table 3) prepared from T₄ (3.39) and T₃ (3.65). Hence, due to better fermentation sugars might have converted into alcohol.

The sharp decreased in T.S.S. in the initial period of fermentation might be due to faster conversion of sugars into alcohol, which was available in maximum amount in the beginning of fermentation. The yeast converts the sugars into alcohol by forming enzymes, pyruvic decarboxylase and alcohol dehydrogenase. Faster rate of fermentation at initial period may also be due to low alcohol levels in the beginning of fermentation. The fermentation rate declines later due to increased quantity of alcohol exerting effect on fermentation process by hindering the activity of yeast.

The fermentation was found to be most active during first five days as indicated by a rapid fall in T.S.S. and the fermentation was found to be terminated at 19th day as indicated by treatment T₆ and T₇ of the must. The treatment T₆ and T₇ took more days (19th day) for fermentation than that of other treatments because of higher acidity of must, which might have hindered fermentation process.

These results are in agreement with the result obtained by the Deshpande *et al.*, (2020) in must of blended wine from grape, guava and noni juice and Patil (1994) in must of grape wine.

Changes in pH during fermentation of banana and kokum must

The pH of the must prepared by blending natural juice of banana and kokum were not adjusted before

Table 3: Changes in pH during fermentation of the must.

Treatments	Colony count in number $\times 10^4$										
	'0' day	1 st day	3 rd day	5 th day	7 th day	9 th day	11 th day	13 th day	15 th day	17 th day	19 th day
T ₁	0	3162	2464	528	105	85	80	-	-	-	-
T ₂	0	2522	2915	482	71	71	70	60	-	-	-
T ₃	0	1264	2825	329	158	132	29	12	-	-	-
T ₄	0	1230	2500	1208	133	119	21	15	-	-	-
T ₅	0	682	166	131	105	75	49	29	12	-	-
T ₆	0	192	307	169	153	131	104	64	62	53	34
T ₇	0	169	226	198	159	151	140	110	60	40	12

fermentation. The changes in pH during fermentation of must are presented in Table 3.

It is seen from the Table that, the pH of must was found to be decreased continuously during fermentation at treatment T₁ and T₂. However, in rest of the treatments it was initially increased and then decreased slowly at later period of fermentation. This decrease in pH of must during fermentation might be due to formation of organic acids during fermentation. Acids are inversely proportional to pH and hence the results. From data of pH at the end of fermentation it was observed that, pH of must decreased from T₁ (3.85) to T₇ (2.78). This might be the impact of initially prepared must where percentage of kokum juice were increased from 0.0 per cent (T₁) to 30.0 per cent (T₇) and hence acidity of blended must (Table 1) increased from T₁ (0.37%) to T₇ (1.58%) and pH of fermented must (Table 3) decreased from T₁ to T₇.

Observations analogous to these findings were also reported by Yadav *et al.*, (2014) in blended must of grape and jamun wine and Deshpande *et al.*, (2020) in must of blended wine from grape, guava and noni juice.

Changes in Yeast count during fermentation of banana and kokum must

The data regarding yeast count during fermentation is presented in Table 4. From this table it is seen that yeast count of treatment T₁ to T₄ increased rapidly till 3rd day of and later on number of colonies decreased till the end of fermentation. However, in case of treatments T₅ to T₇ drastic change in yeast count was not observed. Rapid increase in yeast count upto 3rd day of fermentation and decline later on till the end of fermentation may be due to availability of food i.e. sugars for multiplication of yeast in the initial period of fermentation. The decline

later on may be due to formation of alcohol which hinders the growth and activity of yeast.

From first day data it was interesting to note that the yeast count was found to be decreased from T₁ (3162 $\times 10^4$) to T₇ (169 $\times 10^4$). This might be the impact of acidity of original blended must (Table 1) which was increased from T₁ (0.37%) to T₇ (1.58%). The increase in acidity might have affected the multiplication of yeast cells and ultimately the fermentation process.

The yeast count was taken upto the 19th day of fermentation i.e. till the T.S.S. of fermenting must become constant and did not show any further decrease. At the end of fermentation yeast activity was found to be almost ceased and yeast count varied from 12 (T₃, T₅ and T₇) to 80 $\times 10^4$ (T₁). Similar findings were observed by Chaudhary *et al.*, (2014) in grape and jamun blended wine and Deshpande *et al.*, (2020) in blended wine from grape, guava and noni juice.

Per cent wine recovery

The data regarding per cent wine recovery of banana and kokum blended wine is given in Table 5. It is seen from the data that results were significant with respect to wine recovery.

The wine recovery was found to be increased from T₁ (62.07%) to T₇ (70.13%). This increase in wine recovery from T₁ (100% banana juice) to T₇ (70% banana + 30% kokum juice) may be the impact of kokum juice, which increased from '0' to 30 per cent from T₁ to T₇. For preparation of blended juice, clarified juice of kokum was used from which all suspended material was removed. However, in case of banana, only fine pulp was used and hence suspended material remained in the juice. Hence, at the end when wine was filtered more suspended material was removed from 100 per cent banana juice

Table 5: Per cent wine recovery (%) of wine prepared by blending natural juice of banana and kokum.

Treatments	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)
Wine recovery (%)	62.07	64.68	65.68	65.76	66.17	68.94	70.13
S.E.m. $\pm$				0.54			
C. D. at 1%				2.27			

and it goes on decreasing with increase in kokum juice from T_1 to T_7 . Due to this wine recovery increased from T_1 (62.07%) to T_7 (70.13%). Treatment T_7 was at par with T_6 and significantly superior over others. These results are in agreement with the result obtained by Waradai (2014) in banana based blended wine prepared with jamun, aonla and pomegranate juice.

Conclusion

The present investigation demonstrated that during fermentation, treatment T_4 (85% banana juice + 15% kokum juice) showed the lowest final T.S.S. value of 6.64°Brix at the end of fermentation, indicating maximum utilization of sugars during fermentation. The lowest pH after fermentation was recorded in treatment T_7 (70% banana juice + 30% kokum juice) with a pH value of 2.78. The highest yeast count on the 3rd day of fermentation was observed in treatment T_2 (95% banana juice + 5% kokum juice), recording 2915×10^4 colonies. At the end of fermentation, the maximum wine recovery was obtained in treatment T_7 (70% banana juice + 30% kokum juice) with a wine recovery of 70.13 per cent. The study revealed that blending banana juice with kokum juice significantly influenced the fermentation characteristics and wine recovery. Among the treatments, incorporation of kokum juice improved acidity, reduced pH and enhanced wine recovery, thereby producing a blended wine with desirable fermentation attributes and quality characteristics.

Future Scope

The findings of this study will be highly useful in reducing post-harvest losses of banana and kokum by converting them into a value-added blended wine. There is a need to promote the nutritional and antioxidant potential of banana and kokum through the development of innovative fruit-based beverages. Establishing small-scale fruit wine production units in banana- and kokum-growing regions can generate rural employment, increase farmers' income, and improve the socio-economic status of local communities while encouraging sustainable utilization of surplus fruits.

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