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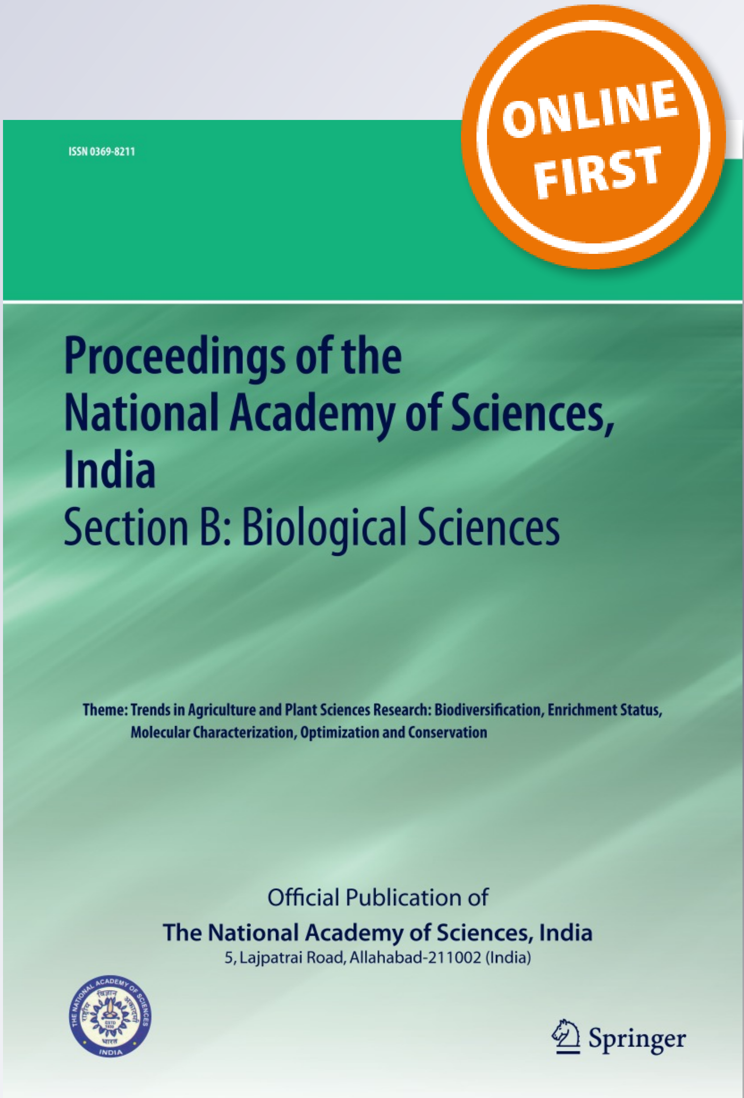

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RESEARCH ARTICLE

Influence of Processing Variables and Storage on the Fruit Drink Developed from Taktir; Wild Fruit of Himalaya

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Abstract Taktir is one of the fruits consumed by the large population of eastern Himalaya and other south east Asian countries. The fruits were harvested in five different harvesting times starting from second fortnight of April to mid of May to adjudge the best maturity time for fresh consumption and processing of fruits. The fruits harvested during 1st week of May were fully matured, rich in sugar, ascorbic acid (16. 54 mg/100 g), overall acceptability (7.46) and edible portion (79.35 %). Different combinations of juice percentage and total soluble solids were tried for the development of drink. A drink with 22.5 % juice and 40°B was found best by a panel of semi-trained judges and excelled in most of the chemical attributes. Taktir drink was further analyzed for chemical composition and microbial safety during 3 months of storage under room temperature and low temperature in day light and dark condition packed in pet and glass bottles. TSS, pH and reducing sugar increased while acidity, ascorbic acid and total sugar dropped off. Anthocyanin was degraded with the increase in storage period. The 'a' value was found to be decreasing as the storage interval increased. However yeast, mould, *E. coli* and total plate counts could not be detected in the beverage. The maximum score (8.1) for over all acceptability was observed with 4 °C Dark PB (pet bottles) at the end of storage period.

Keywords *Garcinia lancifolia* · Fruit drink · Sensory attributes · Microbial safety · Storage

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Introduction

Wild plants are generally rich in protective chemicals like vitamins and minerals. They play an important role in combating the 'silent hunger' in the developing and under-developed countries [1, 2]. Fruits and vegetables play a significant role in the making of balanced human diet providing protection against cellular damage caused by exposure to high levels of free radicals [3–6], and aid in digestion also. At present, fruit beverages have been increasingly gaining popularity amongst different sections of society due to doubt about the health problems by drinking carbonated cola drinks [7]. These beverages are largely being prepared from traditional fruits like mango, orange, pineapple and plum [2, 8, 9]. There is a tendency to prepare such drinks as and when needed at home. Besides rich in nutrient, the colour and taste of taktir make it a good fruit for making fruit juice based beverages.

Among different indigenous fruit trees grown in India, Taktir is one of the fruits consumed by a large population of eastern Himalaya and other south east Asian countries. Taktir (*Garcinia lancifolia.* Roxb) is a shrub, ever green plant, growing up to 5 m height in dense forest, in an altitude range of 515–750 m above msl. It belongs to the family Clusiaceae [2]. Leaves are alternate, petioled and oblong. A tree comes to flowering in Oct-Dec. Flowers are

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pink in colour, perfect and borne in cluster. Fruits mature during April–May with tomato red colour when fully ripen and green at immature stage [10]. Fruits are nonclimacteric, berry, succulent, 1–4 celled and 3–5 seeded. The fruit is rich in tannin and polyphenol showing antioxidant activity. It prevents stomach ache having anti cancerous and anti-inflammatory properties [11]. Its underexploited and unexplored potentials have never been thought of seriously [12]. Therefore, it is no surprise that it is neither grown commercially nor given any attention for product development and commercialization. High growth rate, profuse flowering, good bearing with quality fruits, off season availability and longer shelf life at room temperature make this fruit tree as a potential tree for expanding area under its cultivation and using its fruits for versatile uses. The marketable fruits should have fresh appearance, firm, and uniform colour and free from visual defects. Common post harvest defects in fruits include over maturity, softening, and excess acidity, ripening with internal or external colour changes and blackening of the peel [13]. Information on various qualities of taktir fruits in relation to its harvest maturity is either lacking or scanty. Non availability of suitable technology or lack of standard formulations is one of the reasons for such indigenous beverages not popular in world market. In the present paper, an attempt was made to evaluate the optimum time for harvesting the fruits and to standardize the preparation of taktir fruit juice based beverage. Further it extended to assess the shelf life of taktir fruit drink and to determine the physico-chemical, sensory and microbiological changes during storage under various storage environments.

Material and Methods

The present investigation was conducted at ICAR Research Complex for NEH Region, AP Centre Basar, Arunachal Pradesh during 2008–2011. The detailed methods and techniques used for judging the harvesting maturity, preparation of Taktir based fruit drink and storage conditions are explained below:

Determination of Maturity

Taktir fruits were harvested from the trees in five different periods starting from second fortnight of April which is the normal harvesting time followed by local people to 2nd week of May. The harvesting schedule was as follows; H_1: 15th April, H_2: 23rd April, H_3: 30th April, H_4: 6th May and H_5: 14th May. Different physico-chemical characteristics and sensory attributes were studied to judge the best harvesting time. The fruits harvested at right maturity stage were used for further processing (Table 1).

Extraction of Juice

Mature, firm and ripe taktir fruits were selected, cut into halves and the seeds were removed. The halves were fed into mixer grinder along with skin as the skin was rich in anthocyanin imparting deep red colour to the strained juice. Grinded pulp was passed through the sieve to get the clarified juice.

Preparation of Taktir Based Fruit Drink

Taktir beverage was prepared with different juice percentage (22.5, 25.0 and 27.5 %) and total soluble solids (TSS) (35, 40 and 45°B) as per the treatment combinations given in Table 2. The acidity was kept constant at 1 %. Sugar syrup was prepared separately, strained through muslin cloth, cooled and added to the calculated quantity of taktir juice to maintain the required solids and sugar content. As the juice was rich in acid, external citric acid was not added for the experiment. However, pre standardized amount of acid (if required) and preservatives (650 ppm Sodium benzoate) were added and the drink was filled into cleaned, sterilized and dried bottles of 200 ml capacity, crown corked and processed for 20 min in boiled water. Chemical characteristics and sensory evaluation of the prepared juice were determined and the best treatment combination was selected for further storage studies.

Determination of Storage Conditions

The best treatment was packed in two different bottles i.e. pet bottle (PB) and glass bottle (GB). The bottles were kept in two different storage conditions namely, low temperature (7 ± 3 °C) and room temperature (25 ± 2 °C). The treatment details are as follows; T_1: 4 °C Dark PB, T_2: 4 °C Dark GB, T_3: 25 °C Day Light PB, T_4: 25 °C Day Light GB, T_5: 25 °C Dark PB, T_6: 25 °C Dark GB. The treatments are replicated thrice to validate the results statistically.

Physico-Chemical Analyses

The observations on physical parameters like skin colour, fruit length (cm), diameter (cm), average weight (g), specific gravity, edible portion (%), stone weight (%) and preparatory loss (%) were recorded to identify the optimum harvesting time of the fruits. The TSS was recorded using hand refractometer and the acidity was determined by titrating against standard NAOH solution using phenolphthalein as an indicator and expressed as anhydrous citric acid. Moisture, ascorbic acid, total sugar, reducing sugar and anthocyanin were determined [7]. Colour measurements were carried out using Hunter colorimeter model D25 optical sensor (Hunter Associates Lab Inc., Reston,

Table 1 Effect of harvesting time on physico-chemical characteristics of fresh taktir fruits

Parameters	Harvesting schedule					$CD_{0.05}$
	H_1	H_2	H_3	H_4	H_5	
Skin colour	Slightly red	Red	Deep red	Deep red	Dark red	–
Fruit weight (g)	30.94^{c}	31.37^{c}	37.36^{b}	40.51^{a}	40.94^{a}	2.92
Fruit length (cm)	3.48	3.53	3.62	3.75	3.75	NS
Fruit breadth (cm)	4.63^{b}	4.72^{b}	4.98^{ab}	5.31^{a}	5.44^{a}	0.42
Specific gravity	1.12^{a}	1.07^{b}	1.01^{c}	0.96^{d}	0.95^{d}	0.05
Edible portion (%)	72.31^{d}	76.73^{c}	78.92^{b}	79.35^{a}	77.87^{c}	3.06
Stone weight (%)	11.34^{a}	10.15^{b}	$9.73b^{c}$	$9.64b^{c}$	9.66^{d}	0.51
Preparatory loss (%)	16.36^{a}	12.81^{b}	11.37^{c}	11.06^{c}	12.49^{b}	0.81
Moisture (%)	74.32^{b}	79.25^{ab}	81.33^{a}	82.58^{a}	82.97^{a}	0.72
TSS (°B)	7.27^{d}	7.82^{e}	8.29^{c}	9.22^{a}	8.91^{b}	0.27
pH	1.79^{c}	1.83^{c}	1.97^{b}	2.34^{a}	2.36^{a}	0.07
Acidity (%)	3.58^{a}	3.24^{b}	2.93^{c}	2.11^{d}	2.09^{d}	0.13
Reducing sugar (%)	2.64^{d}	2.97^{c}	3.63^{b}	4.69^{a}	4.73^{a}	0.19
Total sugar (%)	6.28^{d}	7.92^{c}	8.76^{b}	9.87^{a}	10.01^{a}	0.39
Ascorbic acid, (mg/100 g)	11.6^{c}	12.0^{c}	15.45^{b}	16.23^{a}	16.54^{a}	0.59
Overall acceptability	5.15^{d}	5.91^{c}	6.87^{b}	7.46^{a}	7.18^{ab}	0.35

In each row, means with the different superscripts vary significantly by DMRT

PLW physiological loss in weight, *TSS* Total soluble solids

Table 2 Effect of different combination of TSS concentration and Juice percentage on chemical characteristics of drink prepared from taktir fruits

Treatment	TSS (°B)	Juice (%)	pH	Vit C (mg/100 g)	RS (%)	TS (%)	Anthocyanin (OD 535 nm)	Colour		
								L*	a*	b*
T_1	35	22.5	3.13^{a}	15.10	14.51^{c}	33.57^{c}	21.03	77.98	5.72^{a}	14.23^{a}
T_2	35	25.0	3.06^{ab}	15.13	14.35^{c}	33.31^{c}	21.08	78.51	5.65^{ab}	14.11^{a}
T_3	35	27.5	2.93^{cd}	15.16	14.28^{c}	33.14^{c}	21.13	78.23	5.63^{ab}	14.01^{ab}
T_4	40	22.5	2.97^{bcd}	15.12	17.67^{b}	38.72^{b}	20.82	78.44	5.55^{ab}	13.95^{ab}
T_5	40	25.0	2.88^{de}	15.14	17.56^{b}	39.54^{b}	21.29	79.03	5.46^{ab}	13.73^{abc}
T_6	40	27.5	2.81^{e}	15.13	17.42^{b}	39.42^{b}	21.32	78.94	5.42^{b}	13.42^{bcd}
T_7	45	22.5	3.03^{abc}	15.13	19.82^{a}	43.91^{a}	19.96	81.52	5.13^{c}	13.21^{bcd}
T_8	45	25.0	2.95^{cd}	15.15	19.75^{a}	43.92^{a}	20.94	81.11	5.08^{c}	13.15^{cd}
T_9	45	27.5	2.87^{de}	15.17	19.63^{a}	43.86^{a}	21.06	80.23	5.03^{c}	13.08^{d}
CD (0.05 %)	–	–	0.11	0.01	0.80	1.64	0.01	NS	0.29	0.61

In each column, means with the same superscripts do not vary significantly by DMRT

TSS total soluble solids, *RS* reducing sugar, *TS* total sugar, *NS* not significant

VA, USA) on the basis of L*, a* and b*. The instrument (45°/0° geometry, 10° observer) was calibrated against a standard red coloured reference tile (L* = 25.94, a* = 28.98, b* = 11.97).

Microbial Analysis

The product was subjected to microbial study initially and at the end of the storage period of 3 months. The samples were weighed aseptically. Analysis for *E. coli*, yeast, mould and total bacterial counts was carried out on taktir drink. For total yeast and mould count, commercially available potato dextrose agar media (24 g/l) and Martins Rose Bengal Agar media (MRBA) were used. Agar (4.8 g) was dissolved in water (200 ml) in a conical flask with cotton plug and sterilized using autoclave. Plate count agar media (17.5 g/l) and LBCP media were used for total bacterial count and *E. coli* respectively.

Sensory Analysis

Quantitative descriptor analysis (QDA) method was used for sensory profiling of fresh fruits to judge the maturity period, taktir drink immediately after preparation and stored samples as per procedure given by Stone et al. [14]. Descriptors used for sensory analysis of taktir drink samples were developed during initial sessions in which different samples of fruit drink were presented to the panelists. The panelists were asked to describe the samples with as many spontaneous descriptive terms [15]. The common descriptors chosen by at least one third of the panel were compiled along with some significant descriptors found in literature (viz., colour, flavour, sweetness, mouthfeel, body, overall acceptability, staleness, bitterness, sliminess, sourness) [7, 9, 11, 16] and selected for formulation of the score card. The panel consisted of 15 members in the age group of 16–50 years, comprising both male and female who are semi-trained and often involved in sensory evaluation.

Scaling Method

The method of intensity scaling used was QDA. The score card consists of 15 cm QDA scale wherein 1.25 cm was anchored as low (recognition threshold) and 13.75 cm as high (saturation threshold). The panelists were asked to mark the perceived intensity of the attribute by drawing a vertical line on the scale and writing the code. 15 ml of beverage sample labeled with three digit codes was served at room temperature (RT). Only one sample was served at a time and the presentations of the sample were randomized. A duplicate sample was given at each session to check the panel performance. The duplication of the sample was also randomized for each panelist. Water was used as palate cleansing material in between the samples. The intensity scores were calculated and the data were tabulated.

Statistical Analysis

Data collected in the present study was subjected to analysis of variance using the factorial experiment in completely randomized design (CRD) for the quantitative estimation of various physico-chemical characteristics while the data of sensory evaluation was analyzed by randomized block design (RBD). The means were compared using Duncans multiple range test. Statistical analysis was carried out to know the variance for different parameters using AGRES package and significance was identified in both 1 and 5 % level while non-significant results were denoted as NS.

Results and Discussion

Identifying the Optimum Harvesting Maturity for Processing

Effect of harvesting on physico-chemical characteristics of taktir fruits is presented in Table 1. It was lucid that the harvesting maturity recorded profound effect on quality of taktir fruits. The skin colour changed from red to dark red as the growth period extended. The farmers tend to harvest the fruits once it turned red. However, it was observed from the present study that change in colour could not be considered as right maturity index as the chlorophyll disappeared and the red colour appeared concurrently in the initial stage of maturity. Fruit weight increased linearly with the growth period. More fruit weight was observed in H_5 which is at par with H_4. Least fruit weight was recorded in H_1. Nonetheless of increase in fruit length with the progress in growing period, the growth was statistically non- significant. However, fruit breadth varied significantly with the change in harvesting period. Highest fruit breadth was recorded in H_5 followed by H_4. It was observed that most of the changes occurred during H_3. The least fruit breadth was recorded in H_1 and H_2, both being statistically at par with each other. Specific gravity played as an important maturity index for most of the fruits [17, 18]. For taktir, specific gravity below 1.00 showed that the fruit is fully matured. It was observed that the specific gravity decreases with the growing period. Optimum specific gravity was recorded with H_4. Specific gravities of 1.00 and above are generally not considered good for processing, resulting in cooked flavour and comparatively greater metallic absorption and discoloration [9]. Recovery of edible portion is one of the important parameters for profitable processing. It was observed that the highest recovery of edible portion was observed with H_4. It was at par with H_3 (78.9 %) and H_5 (77.8 %). Stone weight declined significantly with the increase in harvesting period. Least stone weight was recorded with H_4. Preparatory loss was more in both under and over maturity. Minimum loss was observed with H_4 (11.06 %). Unlike early stages, in the later stages of ripening, as the pulp percentage increased, recovery of pulp became easier, leaving traces of pulp adhering to pomace. Again, with further ripening, due to disintegration of tissues of juice, the pulp remains with the peel which led to an increase in preparatory loss. Concurrent observations were recorded by Sharma et al. [17] in apricot.

Slightly higher moisture content was observed in soft ripe fruits than in unripe fruits. This could be due to higher respiration rate and greater water holding capacity of sugars and pectin in soft ripe fruits as compared to starch and protopectin in hard, unripe fruits. Analogous observations were recorded by Suresh Kumar et al. [9]. TSS increased with the rise in harvesting period which might be due to hydrolysis of polysaccharides into simple sugars. Rapid reduction in acidity was observed as the extension of harvesting period. Similar observation on acidity was observed by Kumar and Manimegalai [18]. pH of taktir fruits increased with the extension of harvesting period. This increase was concurred with the corresponding decrease in acidity. However, the fruits were very high in inherent acidity. Ripening generally leads to increase in sweetness. It usually results from the release of simple sugars from starch or other reserve carbohydrates and the inter conversion of released sugars. Analogous observations on various chemical parameters were observed by Kumar and Manimegalai [18–21]. Ascorbic acid increased gradually with the extending harvesting period. Sensory score increased with the increase in harvesting period. Decrease in acidity and increase in sugar improved the taste and flavour of the fruits. Colour and mouth feel increased the overall acceptability of the fresh produce [9, 22].

Evaluation of Taktir Drink

Fruit drink was prepared from the fruits harvested in the first week of May (H4). Different combination of taktir juice and TSS and their effect in quality and sensory attributes are presented in Tables 2 and 3. The pH of the produced drink revealed that high pH was observed with T_1 while the least pH was observed with T_6. pH of the produce varied according to the ratio of sugar and juice percentage. Optimum pH was observed with T_4, it was at par with T_3 and T_7. A change in ascorbic acid content with different treatments was not significant. However, the ascorbic acid content decreased considerably by processing. Ascorbic acid is sensitive to heat and is oxidized quickly in the presence of oxygen. Hence it might have destroyed during processing and subsequently during storage period due to its oxidation [14]. It was observed that the sugar added to the produce significantly changed the reducing sugar and total sugar content of the drink irrespective of treatments. Highest level was viewed with T_8, T_7 and T_9 which were processed with higher concentration of sugar. Similar result was observed by Gehlot et al. [20] in bael-guava blended RTS beverage. Opposite to this, low sugar level was observed with T_1–T_3. Anthocyanin content and L value did not vary with the change in process variables. a' and b' values varied according to the process variables.

The prepared drinks were further evaluated for various sensory qualities for the standardization the best rated fruit drink. Data in Table 3 revealed that the highest colour score (8.4) was recorded with T_4 followed by T_7 (8.0). Least values were viewed with T_3 (6.2) followed by T_2. The sourness should be less for better acceptability of the produce. High sourness was observed when the sugar concentration was less. Higher sourness was observed in T_3 which is at par with T_2. Flavour score was highest in T_4 (8.6) and lowest in T_3. Decrease in flavour with the increase in juice concentration might be due to increase in raw flavour of taktir which was disliked by the panelists. Though the staleness did not vary among the treatments least score was observed with T_4 which was desirable for the acceptance of produce. Bitterness increased with the increase in juice percentage. It can be concluded that products with high juice percentage had higher tannin that lowered the acceptability for taste. Similar results were observed by Barwal et al. [7] in preparation of bitter gourd based RTS drink. Highest score for overall acceptability was obtained by T_4 that differed significantly with other treatments. It was observed that the drink prepared with 22.5 % juice and 40 °B yielded good quality, delicious drink to other treatments. This treatment was adjudged best by the panelists due to its acceptable juice/sugar blend and retaining characteristic flavour of the fruits.

Evaluation of Storage Conditions

The standard drink was prepared in more quantity to study the storability of the produce with varying storage environments (Tables 4, 5). TSS, reducing sugar, and pH increased whereas acidity, vitamin C, anthocyanin and total sugar decreased with the storage period. The TSS did not show significant change in storage. However, the slight increase in TSS during storage might be due to the hydrolysis of polysaccharides into monosaccharides and soluble disaccharides [7, 23]. The gradual decrease in the acidity and reduction in pH of the beverage were observed during storage [24]. However the reduction was less when the samples were stored under low temperature with dark condition (T_1 and T_2). The reduction in acidity of RTS beverage of mango and jackfruit were reported by Bajwa et al. [21] and Krishnaveni et al. [12] respectively. Decrease in acidity during storage was due to co-polymerization of organic acids with sugars and amino acids and loss of volatile acid [7, 25]. The difference in acid development with various packages was due to the difference in conversion of sugar into acids. The change was more when the samples were kept under room temperature (T_3 and T_4). Generally dark condition favoured to retain the nutrients and impart lesser changes in chemical constituents.

A significant decrease in ascorbic acid was noticed during storage in all the treatments which was due to the formation of dehydroascorbic acid or furfural or dehydroxy methyl furfural [8, 26]. This loss may be further due to the effect of storage temperature and catalytic activity of fructose like sugars in the catabolization of ascorbic acid. However, the change was comparatively less under low temperature condition irrespective of packages (T_1 and T_2). Both pet and

Table 3 Effect of different combination of TSS and Juice on various sensory descriptors of drink prepared from taktir fruits

Treatments*	Colour	Sourness	Flavour	S	B	Body	Staleness	AT	Sliminess	DA
T_1	7.6^{c}	3.8^{b}	8.2^{b}	7.9^{c}	3.7^{c}	8.0^{b}	3.1^{bc}	7.7^{c}	3.9^{b}	7.8^{bc}
T_2	6.6^{de}	4.2^{a}	7.5^{d}	7.1^{de}	4.5^{a}	7.2^{d}	3.6^{b}	7.1^{e}	3.7^{bc}	6.9^{e}
T_3	6.2^{e}	4.2^{a}	7.4^{d}	6.9^{e}	4.6^{a}	6.6^{e}	3.9^{a}	6.7^{f}	4.3^{a}	6.4^{f}
T_4	8.4^{a}	3.3^{d}	8.6^{a}	8.5^{a}	3.1^{e}	8.3^{a}	1.7^{d}	8.2^{a}	2.1^{f}	8.4^{a}
T_5	7.9^{c}	3.8^{b}	8.3^{b}	8.0^{b}	3.6^{cd}	8.0^{b}	3.1^{bc}	7.9^{b}	2.8^{ef}	7.9^{bc}
T_6	6.9^{d}	4.0^{ab}	7.7^{cd}	7.2^{d}	4.5^{a}	7.3^{d}	3.5^{b}	7.2^{e}	4.3^{a}	7.1^{de}
T_7	8.0^{b}	3.7^{bc}	8.4^{ab}	8.1^{b}	3.4^{d}	8.2^{ab}	2.4^{d}	8.1^{a}	2.3^{f}	8.1^{b}
T_8	7.5^{c}	3.8^{b}	8.1^{bc}	7.8^{c}	3.8^{c}	7.9^{c}	3.2^{bc}	7.7^{cd}	3.3^{e}	7.6^{c}
T_9	7.3^{cd}	3.9^{b}	7.9^{bcd}	7.3^{d}	4.2^{b}	7.5^{d}	3.5^{b}	7.5^{d}	3.8^{b}	7.4^{cd}
$CD_{0.05}$	0.21	0.05	0.25	0.32	0.07	0.36	0.24	0.54	0.45	0.34

* Treatments are as in Table 2

In each column, means with the same superscripts do not vary significantly by DMRT

S sweetness, *B* bitterness, *AT* after taste, *DA* degree of acceptability, *NS* not significant

Table 4 Effect of different storage conditions on chemical characteristics of drink prepared from taktir fruits during storage of three months

Treatment	TSS (°B)				pH				Acidity (%)				Vit C (mg/100g)				Anthocyanin (OD 535 nm)			
Months	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
T1		40.0	40.2	40.4		3.03	3.04	3.09		0.97	0.95	0.95		14.9	14.7	14.6		20.9	20.4	20.2
T2		40.1	40.2	40.3		2.98	3.06	3.09		0.96	0.95	0.95		14.8	14.4	14.5		20.7	20.3	20.0
T3	40.0	40.2	40.3	40.3	2.97	3.13	3.11	3.21	1.0	0.94	0.96	0.92	15.1	14.5	14.0	13.6	21.1	20.4	19.8	19.4
T4		40.3	40.3	40.3		3.10	3.11	3.22		0.94	0.95	0.91		14.4	14.1	13.3		20.4	19.4	19.2
T5		40.3	40.4	40.5		3.08	3.09	3.13		0.95	0.94	0.94		14.7	14.3	14.1		20.6	20.2	19.9
T6		40.3	40.3	40.3		3.01	3.05	3.14		0.95	0.94	0.94		14.6	14.2	14.0		20.5	20.0	19.7
$CD_{0.05}$																				
T		NS	NS	NS		0.04	0.05	0.09		0.02	0.01	0.02		0.41	0.37	0.38		0.72	0.74	0.63
SC		NS	NS	NS		0.01	0.04	0.09		0.01	0.01	0.01		0.33	0.24	0.21		0.35	0.42	0.31
P		NS	NS	NS		NS	0.01	0.04		NS	NS	NS		0.24	0.03	0.05		0.17	0.19	0.06
T × SC		NS	NS	NS		0.13	0.09	0.13		0.04	0.02	0.01		0.57	0.53	0.54		1.01	1.04	1.05
T × P		NS	NS	NS		0.02	0.07	0.14		0.02	0.02	0.02		0.42	0.53	0.26		0.46	0.76	0.73
SC × P		NS	NS	NS		NS	0.05	0.06		0.02	0.02	0.02		0.33	0.52	0.14		0.38	0.45	0.17
CP		NS	NS	NS		0.17	0.12	0.18		0.06	0.03	0.03		0.81	0.74	0.77		1.44	1.06	1.13

T_1: 4 °C Dark PB, T_2: 4 °C Dark GB, T_3: 25 °C Day Light PB, T_4: 25 °C Day Light GB, T_5: 25 °C Dark PB, T_6: 25 °C Dark GB

T temperature, *SC* storage condition (Day and Dark), *P* package, *GB* glass bottle, *PB* pet bottle, *CP* cross product (T × SC × P)

glass bottles exercised the same changes in ascorbic acid content. Storage studies clearly indicated that anthocyanin degraded with the increase in storage period. The results obtained with taktir drink stored at different temperatures were in accordance with the previous reports on other food products. The extent of anthocyanin degradation increased with solid content. Sugar and its degradation products accelerated the anthocyanin breakdown. This may be due to the detrimental effect of fructose produced by the hydrolysis of sucrose to fructose. Storage temperature had a clear effect on degradation kinetics of monomeric anthocyanin content of coloured model juices. Room temperature storage (25 °C) resulted in the higher degradation rate as compared to refrigerated temperatures (4 °C). Sugars are probably active in the form of their degradation products. The sugars such as fructose which degrade most readily in acid medium show the most marked effect on the rate of pigment degradation [27]. An increase in sugar concentration (such as in squash) also resulted in an increase in the rate of pigment degradation. These findings are in agreement with Rommel et al. [23] who reported that anthocyanin the red pigments in raspberry and other fruits, degraded and polymerized easily with time. Thus, the stability of anthocyanins and the rate of their degradation were markedly influenced by temperature and formation of chalcone is flavoured by increasing temperature during storage and processing [22].

Table 5 Effect of different storage conditions on chemical characteristics of drink prepared from taktir fruits during storage

Treatment*									L*				a*				b*			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
T1	17.6	17.6	17.8	17.9	35.7	35.3	35.0	34.7	78.4	78.5	78.8	78.9	5.6	5.3	5.2	5.0	13.9	13.7	13.5	13.6
T2		17.7	17.9	18.1		35.2	34.9	34.6		78.7	78.7	78.9		5.1	4.9	4.8		13.8	13.7	13.6
T3		18.1	18.5	18.7		34.8	34.4	33.3		78.3	78.5	78.7		4.9	4.6	4.5		13.6	13.5	13.3
T4		18.4	18.6	18.9		34.7	34.3	33.2		78.2	78.5	78.6		4.8	4.7	4.5		13.5	13.4	13.2
T5		17.8	18.1	18.3		35.4	34.5	34.1		78.4	78.6	78.8		5.0	4.9	4.7		13.6	13.4	13.3
T6		17.9	18.3	18.5		35.3	34.6	34.0		78.5	78.7	78.9		5.0	4.8	4.6		13.5	13.4	13.1
$CD_{0.05}$																				
T		0.05	0.05	0.07		0.23	0.33	0.21		0.12	0.15	0.04		0.07	0.08	0.09		0.25	0.27	0.20
SC		0.02	0.03	0.12		0.09	0.13	0.20		0.09	0.05	0.05		0.05	0.04	0.07		0.12	0.09	0.15
P		NS	NS	0.01		NS	0.05	0.09		NS	0.04	NS		0.02	0.06	0.01		0.04	NS	NS
T × SC		0.10	0.23	0.35		0.43	1.03	0.34		1.20	0.45	0.26		0.10	0.11	0.12		0.34	0.37	0.24
T × P		0.08	0.09	0.25		0.33	0.43	0.45		1.13	0.33	0.25		0.10	0.11	0.12		0.34	0.28	0.18
SC × P		0.07	0.13	NS		0.55	0.57	0.53		1.20	0.62	0.47		0.10	0.11	0.12		0.34	0.17	0.09
CP		0.24	0.36	0.92		1.32	1.28	1.12		2.11	1.30	1.08		0.14	0.16	0.18		0.49	0.53	0.40
CV, %		3.62	3.29	4.63		6.23	3.17	3.01		3.02	2.22	5.32		4.32	2.51	5.43		4.73	5.98	5.43

Treatments are as in Table 4

Reducing sugar increased with the storage period (Table 5). However the variation was less in the samples stored under low temperature (T_1 and T_2). Minimum conversion in low temperature was due to better protection against chemical conversion arresting the activity of enzymes. Reducing sugar content of Jackfruit increased gradually [11]. Increase in reducing sugars during storage might be due to the hydrolysis or inversion of non-reducing sugars to reducing sugars [7, 9]. Gehlot et al. [20] ascribed that the increase in reducing sugar indicate the inversion of sucrose under acidic conditions. Packaging also exerted significant effect on reducing sugars. Total sugar content of the produce decreased after 3 months of storage. This loss of total sugar may be due to maillard reaction and other chemical reactions of sugar in the presence of acids [19]. The result clearly showed that there was a significant change in the colour of the squash based model solutions in light and temperature conditions as well as during storage for 3 months. The 'a' value which gave depth of redness was found to be decreasing as the storage interval increased. Further, the effect of temperature and light condition on the change of colour revealed that as the temperature increased, the 'a' value decreased, however, under dark conditions the rate of colour change was lesser as compared to day light. However, the 'L' value increased as the temperature increased under day light condition. These findings are in agreement with Cemeroglu et al. [26]. According to Skrede [27] day light storage of syrups lowered half-life of Hunter 'a' values by 10–30 % as compared with dark storage which was in line with the observations recorded. It has also been demonstrated that the concentration of polymeric pigments increased with temperature and storage time, and this has an important influence in the colouration of juices and the red wine [28]. In this aspect, it was remarkable that the rate of colour loss was much slower than the rate of anthocyanin degradation.

The beverages have a pH of 3.4 and acidity of around 1 % and have a chance of contamination during processing and capping. However yeast, mould, *E.coli* and total plate counts could not be detected in the beverage indicating that the beverage was microbiologically safe as analysis was done at 30 days interval for 3 months. However, 1–2 × 10^{-5}/g yeast was observed in the samples stored under room temperature (T_3 and T_4) kept in day condition. Similar observations were recorded by Lakshmi et al. [8] in RTS beverages from jack fruit. The microbial analysis of the stored beverage in refrigerated condition indicated the presence of 1–2 × 10^{-6} bacteria, 1–2 × 10^{-4} fungi and 1 × 10^{-5}/g yeast in papaya RTS [20].

Sensory descriptive score of the stored sample at the end of storage period was illustrated in Fig. 1. The maximum score (8.1) for over all acceptability was observed with T_1 at the end of storage period. Khurana and Anand [25] observed similar results while developing phalsa beverage. The positive sensory attributes like colour, flavour, sweetness, body, after taste and degree of acceptability was higher with T_1 which was at par with T_2. Low temperature storage under dark condition imparted better score for these parameters [28]. Concurrently least score for negative attributes like bitterness, staleness and sliminess was low in the same treatment combinations. The increase in temperature reduced the sensory score. However, the least score

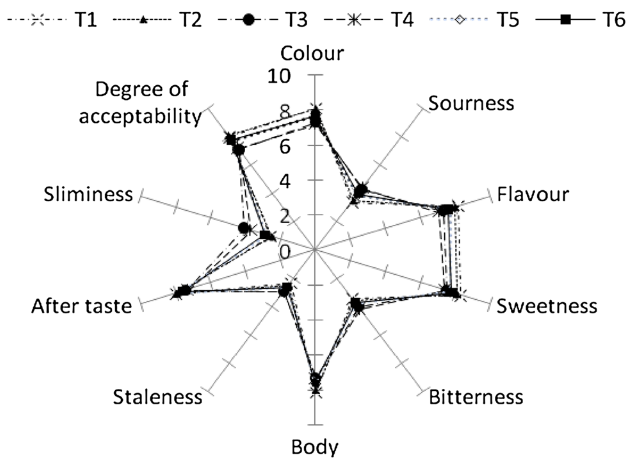

Fig. 1 Effect of different storage conditions on sensory attributes of taktir fruit juice based drink after 3 months of storage T_1: 4 °C Dark PB, T_2: 4 °C Dark GB, T_3: 25 °C Day Light PB, T_4: 25 °C Day Light GB, T_5: 25 °C Dark PB, T_6: 25 °C Dark GB

was recorded in the samples which were stored under day light condition (T_3 and T_4). Decrease in flavour score could possibly be due to the loss of volatile aromatic substances [8, 22]. Data showed that the after taste had higher score in the fresh sample and gradually decreased as the storage progressed up to 90 days. This trend prevailed in samples stored at 27 °C as well as 4 °C. But the decrease in after taste was more in case of RT stored samples than those stored at low temperature. The probable cause for lower acceptability was due to the increase in acidity of the product. Similar result was reported by Branger et al. [29] in grape fruit.

Conclusion

Commercialization of different types of products including beverage is another way of utilization of the wild fruits. It was observed from the study that 1st week of May was the best time for harvesting the taktir fruits for both fresh use and processing purposes. As the fruit was rich in inherent acidity, 40 °B and 22.5 % juice combination was the best to produce fruit drink beverages. It should be stored under refrigerated condition to retain the chemical content and to fetch higher sensory attributes. It may be packed either in pet bottles or glass bottles. But pet bottles were good as they withstood for long transport and were significantly cheaper in cost.

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References

1. Padulosi S, Hodgkin T, Williams JT, Haq N (2001) Underutilized crops: trends, challenges and opportunities in the 21st century. IPGRI, Rome, p 222
2. Suresh Kumar P, Choudhary VK, Bhagawati R, Devi MP, Bagra G (2013) Underutilized fruits and vegetables crops of Arunachal Pradesh. In: Prakash N, Roy SS, Sharma PK and Ngachan SV (Eds) Developing the potential of underutilized horticultural crops of hill regions. p 600. Today and Tomorrow's printers and publishers, New Delhi, p 127–169
3. Ames BN, Shigenaga MK, Hagen TM (1993) Oxidants, antioxidants, and the degenerative diseases of aging. Proc Natl Acad Sci USA 90:7915–7922
4. Dillard CJ, German JB (2000) Phytochemicals: nutraceuticals and human health. J Sci Food Agric 80:1744–1756
5. Prior RL, Cao G (2000) Antioxidant phytochemicals in fruits and vegetables: diet and health implications. Hortic Sci 35:588–592
6. Bharathi LK, Singh HS, Shivashankar S, Ganeshamurthy AN, Suresh Kumar P (2014) Assay of nutritional composition and antioxidant activity of three dioecious *Momordica* species of South East Asia. Proc Natl Acad Sci India Sect B Biol Sci 84(1):31–36
7. Barwal VS, Singh TK, Alkesh V (2005) Studies on processing and development of ready to serve drink from bittergourd fruit. J Food Sci Technol 42(3):217–220
8. Lakshmi K, Vasanth Kumar AK, Rao LJ, Naidu MM (2005) Quality evaluation of flavoured RTS beverage and beverage concentrate from tamarind pulp. J Food Sci Technol 42(5):411–415
9. Suresh Kumar P, Sagar VR, Singh U (2008) Effect of ripening stages on osmo-dehydrated guava slices. J Food Sci Technol 45(6):546–548
10. Chen CH, Chu YT, Ho HY, Chen PY, Lee TZ, Lee CK (2009) Antioxidant activity of some plant extracts towards xanthine oxidase, lipoxygenase and tyrosinase. Molecules 14:2947–2958
11. Lalfakzuala R, Lalramnghinglova H, Kayang H (2007) Ethnobotanical usages of plants in western Mizoram. Ind J Tradit Knowl 6(3):486–493
12. Krishnaveni A, Manimegalai G, Saravankumar R (2001) Storage stability of Jack fruit RTS beverage. J Food Sci Technol 38:601–602
13. Srivastava JS (1998) Comparative study of RTS drink prepared from *Dashehari* and Banganapalli mangoes. Ind Food Packer 52(2):38–40
14. Stone H, Sidel J, Oliver S, Woolsey A, Singleton RC (1974) Sensory evaluation of quantitative descriptive analysis. Food Technol 28(11):28–34
15. ASTM (1996) Sensory testing methods. In: Chamber IV E, Wolf MB (eds) ASTM, MNL, 26, 2nd edn. ASTM, Philadelphia
16. Gowda IND, Huddar AG (2004) Investigations on processing quality of some mango varieties; hybrids and their blends. J Food Sci Technol 41(2):154–159
17. Sharma R, Barwal VS, Kaushal BBL (2003) Preparation and evaluation of dietic plum seasoned squash. Beverage Food World 30(2):38–40
18. Kumar SR, Manimegalai G (2005) Studies on storage stability of whey based papaya juice blended RTS beverage. J Food Sci Technol 42(2):185–188
19. Suresh Kumar P, Kanwat M, Choudhary VK (2013) Mathematical modelling and thin-layer drying kinetics of bamboo slices on convective tray drying at varying temperature. J Food Process Preserv 37:914–923

20. Gehlot NR, Singh R, Rana MK (2008) Changes in chemical composition of ready-to-serve bael-guava blended beverage during storage. J Food Sci Technol 45(4):378–380
21. Bajwa U, Gupta M, Sandhu KS, Ahluwalia P, Sahota PP (2005) Changes in physico-chemical, sensory and microbiological characteristics during storage of carrot-milk cake in various packages. J Food Sci Technol 42(2):119–126
22. Rodriguez-Soana LE, Guisti MM, Wrolstad RE (1999) Colour and pigment stability of red radish and red fleshed potato anthocyanins in juice model systems. J Food Sci 64(3):451–456
23. Rommel A, Heatherbell DA, Wrolstad RE (1990) Red raspberry juice and wine: effect of processing and storage on anthocyanin pigment, composition, colour and appearance. J Food Sci 55(4):1011–1017
24. Jackman L, Smith JL (1996) Anthocyanins and betalains. In: Hendry GAF, Houghton JD. (eds.) Natural food colourants, 2nd edn. Blackie Academic and Professional, London, p 244-280
25. Khurana DS, Anand JC (1980) Changes in chemical constituents and orgnaoleptic quality for heat processed phalsa beverage during storage in glass bottles. J Food Sci Technol 18:160–161
26. Cemeroglu B, Velioglu S, Isik S (1994) Degradation kinetics of anthocyanins in sour cherry juice and concentrate. J Food Sci 59(6):1216–1218
27. Skrede S (1985) Color quality of blackcurrant syrups during storage evaluated by hunter L', a', b' values. J Food Sci 50:514–525
28. Bakker J, Timberlake CF (1985) The distribution of anthocyanins in grape skin extracts of port wine cultivars as determined by high performance liquid chromatography. J Sci Food Agric 36:1315–1324
29. Branger EB, Slims CA, Schmid RM, Keefe SPO, Cornell JA (1999) Sensory cahracterstics of cottage cheese whey and grapefruit juice blends and change during processing. J Food Sci 64:180–184