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Comparative investigation of Star Fruit: A healthy underutilized medicinal component

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ABSTRACT

Tropical and sub tropically grown star fruit (*Averrhoa carambola* L.) is generally being used as raw vegetable and ripe fruit. Though its perishable nature is a cause to think when it comes about storage, researchers are having successful results regarding storage and acceptability of the value added food products using star fruit. Food products like jam, squash, and pickle were formulated and believed to be a good source for healthy taste twister. Development of such food products are also low cost and could be in reach to below poverty lined population as well, providing them to thrive a home-based healthy start up to balance their financial scenario. Whole star fruit plant is believed to be a traditional herbal medicine. Proper utilization of the antimicrobial, antioxidant, hypoglycemic, antidotal and many more beneficial properties of this therapeutic plant, especially its fruit will not only help to upgrade the medicine world, also will combat toxic effects of artificial drugs. This current review includes origin, distribution, cultivation, medicinal properties, phytochemical contents along with the in progress research studies on star fruit.

1. Introduction

In the area of herbal medicine and its accomplishment in clinical practices, it is very much essential to gain knowledge and documentation of botanical and pharmacological data to carry on further researches from different parts of the world to amplify the large-scale significance. In case of indirect or direct derivation of several drugs, plant sources are always been an ideal one[1]. Traditional medicinal practices and ethno botanical sources have often used as root origin of ancient medicines to treat mild to chronic diseased conditions. According to the World health organization (WHO) 80% of the population in developing countries are solely dependable upon traditional medicine for their prime health care[2]. Among 21000 exclusively useable medicinal plant species, in India all most 2500 sources belongs to more than 100 genera have imperative implication in pharmaceutical aspects[3]. Export of these curative plants in respect of both magnitude and worth from India made it to come up to 2nd rank[4]. At present scenario, most of the population is suffering from fatal or chronic diseases, resistant infections, autoimmune disorders, degenerative problems. Although up to date and classy allopathic system has been budding day by day, expensive methodologies make it beyond the reach of common man along with its toxicological effects on health. In comparison to this synthetic drug system, plant sources are much safer, less expensive with manageable counter effects than allopathic medicines[5]. Unquestionably, this effective, therapeutic valued flora contains too many botanical species that are yet to be revealed[6].

Among these traditional vegetations, the Oxalidaceae family carries noteworthy therapeutic value. It possesses seven genera that correspond to more than two hundred species, scattered primarily in the tropical and subtropical regions[7]. One of these is genus *Averrhoa*, that contains two species, bilimbi (*Averrhoa bilimbi* L.) and carambola (*Averrhoa carambola* L.). carambola is generally known as star fruit, consists of considerable significance. The fruit became commercially well known crop in the United State by 1985[8], though the selection and improvement of cultivars was started up in Florida in 1935[9].

The Sanskrit word 'karmaranga' derived name of carambola means "food appetizer". This is oval shaped and crisp textured fruit with 5 grooves and sweet in taste. Though carambola was Malayalam version of star fruit, Portuguese kept the original name after taking it to Africa and South America[10-14]. This fruit is generally believed to be classified as the vegetation in tropical and subtropical environments as mature plants in spite of having tolerating capability in freezing temperature, get minor damages occur at 27° F (-2.78° C). It needs moisture to grow properly along with ideal rainfall on sand, heavy clay or limestone and loam rich soil with pH 5.5 – 6.5 and survives up to an altitude of 4000 feet (1200 m). The most appreciable method that is considered to be involved in the propagation of star fruit is, budding and grafting [15,16].

2. Origin and distribution

Ceylon and the Moluccas have been considered to be the foundation of the star fruit, but the nurturing was also in Southeast Asia and Malaysia for hundreds of years.

Sri Lanka, Southern China, Taiwan, Philippines, Queensland, Australia, Malaysia, Thailand, Israel, Florida, Brazil, Indonesia, in some of the South Pacific islands, particularly Tahiti are the most available place to find out this fruit. As it is well cultivated in the warmer parts of India, southern states along the west coast, extending from Kerala up to the West Bengal are well known for star fruit.

Root of this fruit is considered to be either in Sri Lanka or the Moluccas (Islands of Indonesia) and it had been spread through north and South America. To separate it from the fruit bilimbi, star fruit was well known as balimbing, belimbing or belimbing manis (sweet belimbing). After wards its popularity increases not only as a decorative fruit but also as commercial one [17-19].

3. Nutritional components and health beneficial facets

Fresh fruits and vegetables are considered to be a great health promoting factor [27] and star fruit is one of them. It is believed to be a future phase of medicinal practices due to its enormous health beneficial characteristics. It is very much helpful in weight loss because of favorable amount of fiber and low calorie content (30 calorie per fruit). By reason of a good source of vitamin B9 (folic acid), it is also helpful in the reduction of risk management in heart diseases and strokes. Considerable amount of vitamin B-complex in it is also profitable in case of hair growth along with its protection to keep it strong and healthy. As a traditional herbal medicine, it has so many valuable uses. It has been used for hangovers and sunburns as home remedies along with the treatment of cough, fever, ulcers and sore throats. Apart from the fruit, leaves of this plant are also curative. Leaves are primarily supportive to treat stomach ulcers by improving digestion. Ripe fruits are also directed to get relieved in hemorrhoids and hemorrhages [28-32]. Intake of this fruit also combats blood pressure and lower down the cholesterol level [33]

According to a study by Luximon- Ramma et al [43] antioxidant activities of carambola (star fruit) was from in the range of 11 to 17 µmol Trolox equivalent antioxidant capacity (TEAC)/g fresh weight and 9-22 µmol ferric reducing antioxidant power (FRAP)/g fresh weight, for the acid and sweet fruits respectively. Total phenolics content was recorded as 1429 and 2099 µg/g fresh weight, total flavonoids 103 and 148 µg/g fresh weight. It had been noticed that involvement of flavonoids was less along with poor correlation between ascorbate content (190 and 144 µg/g fresh weight) and antioxidant activity, concluding star fruit a generous foundation of phenolic antioxidants. In another research work [44], it had been observed that the discarded residue of star fruit during juice drink processing is a potential source of antioxidants (70% total antioxidants).

The ethanol extract of *A. carambola* leaves was examined along with other phytochemical constituents, such as, its hexane,ethyl actate, butanol fractions and two flavonoids, apigenin-6-C-β-l-fucopyranoside and apigenin-6-C- (2″-O-α-l-rhamnopyranosyl)-β-l-fucopyranoside to check the anti-inflammatory activity. Based upon the experiment it had been shown up that the ethanol extract was very much helpful in the reduction of edema in a dose-dependent manner, followed on in a maximum inhibition, though rest did not show any significant effect[45].

Acetylcholinesterase inhibitory activity was also noticed when various organs of Sprague Dawley (SD) rats were fed star fruit juice and kept at different storage conditions [46]**.** In a study[47] it had been discovered antimicrobial as well as antifungal activity from the methanol extract of *A. carambola*. Antitumor activity[48], antiulcer activity of the leaves[49] along with the negative inotropic and chronotropic effect were recorded[50]. A new approach was recommended a research that, micronization of the fruit may be supportive in the enhancement of physiological functions of food fibers in fiber-rich functional food applications[51]. Hypoglycemic activity is also one of the health-beneficial characteristics of the leaves extraction of the fruit, carambola[52]. In a preliminary study[53] it also had been told that having star fruit juice twice a day for the duration of a month might improve the antioxidant status of elderly age group as well as the vitamins level due to the enhanced level of lipoprotein related to vitamin C and A in the fruit. Usage of star fruit as an antidote in the fluoride endemic region is also considerable according to a study[54]**.**

4. Counter effect upon consumption in certain health conditions

In spite of having so many curative facets, some toxicological activities are also observed in certain scenario due to consumption of the edible part of the star fruit. Based upon some proven fact it's also has been suggestible that consumption of such extracts might induce electrical and mechanical changes, also known as electrphysiological effects[55]. Neto et al [56] analyzed the experiment, done upon the renal patient without dialysis and came to the conclusion that consumption of the fruit induces nephrotoxicity along with neurotoxicity[57] leading to fatal conditions. Normal individuals are also advised not to have a large amount of the fruit in empty stomach.

5. Phenotypic and genetic characteristics of carambola plant

Assessment of the analyzed correlation in between eight collected varieties was done to characterize them phenotypically as well as genetically by Priadi et al [58]**.** NT-SYS software was used to point out the phenotypic relation resulting in discovery of three clusters of those collected varieties and RAPD markers using 10 primers for that of genetic purposes with the outcome of 96% of similarity between Malaysia and Penang varieties. This study was primarily done to upgrade the plant collection database.

6. Value added food products and their storage ability

In a study, value added food products formulation from star fruit was done to find out the prospects in market and enhanced storage environment at 25-34ºC, 10ºC and 0ºC storage temperatures for 6 months. This study showed that formulated jam and squash could be stored almost for 3months without doing any sort of changes. In respect with increase in time of storage, TSS and acidity also seem to be increased, besides having lesser content of moisture, pH and vitamin C [59,60].

One more study was conducted to record the physic-chemical characteristics of carambolafruit juice from ripened and unripened form to review the aptness of the fruit for the production of wine. According to the observation, sugar and yeast starter culture was much more helpful in the increment of alcohol content[61]**.**

In another study[62], the formulated sweet star fruit and sour star fruit jam was also examined and evaluated at different storage intervals leading to acceptable colour, taste, texture of the products.

7. Discussion

Due to its perishable nature, star fruit did not get that much popularity in commercial aspect in spite of being an important traditional medicinal fruit and considered to be a usual one. But now a day, a lot of research studies are going upon this fruit and its other curative part viz., leaves, bark. It possesses a significant prospective not only for the use of medicinal purpose but also as the food processing items. Toxic effects along with the expenses of the synthetic drugs could be easily overcome using traditional herbal medicines and star fruit is one of the sources of that herbal therapeutics to combat fatal diseases. Proper knowledge and more detailed investigation regarding storage of the formulated food products besides utilizing its health beneficial facets will be more helpful to make star fruit a potential upcoming medicinal candidate.

Abbreviation:

- WHO = World health organization
- TEAC = Trolox equivalent antioxidant capacity
- FRAP = Ferric reducing antioxidant power
- SD rats= Sprague Dawley rats
- RAPD= Random amplified polymorphic DNA
- NT-SYS= Numerical Taxonomy and Multivariate Analysis System.
- TSS= Total soluble solids

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TABLES & FIGURES

Table I: Other popular names of *Averrhoa carambola* [20, 21]:

Sanskrit	Karmaranga
English	Starfruit, Chinese gooseberry
Hindi	Kamrakh,Karmal
Bengali	Kamranga
Assamese	Kordoi/ rohdoi
Gujarati	Kamrakh
Marathi	Karambal
Telugu	Ambanamkaya
Tamil	Thambaratham/Tamarattai
Malayalam	Caturappuli
Sinhala	Kamaranga
Filipino	Balimbing, saranate
Indonesian	Belimbing
Malay	Belimbing

Table II: Taxonomical classification of *Averrhoa carambola* [22-26]:

Scientific Name	*Averrhoa carambola*
Kingdom	Plantae
Subkingdom	Tracheobionta -Vascular plants
Superdivision	Spermatophyta
Division	Magnoliophyta–Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Rosidae
Order	Geraniales
Family	Oxalidaceae–Wood-Sorrel family
Genus	*Averrhoa* Adans. – averrhoa
Species	*Averrhoa carambola* L. – carambola

Table III: Nutritional breakdown of *Averrhoa carambola* [34,35].

Nutrients	**Value per 100 mg**
Calories	35.7
Water	92%
Cholesterol	0 mg
Moisture	89000-91000 mg
Protein	380 mg
Fat	80 mg
Carbohydrate	9380 mg
Fiber	0.80-0.90
Minerals	
Calcium	4.4-6.0 mg
Phosphorous	15.5-21.0 mg
Iron	0.32-16.5 mg
Ash	0.26-0.40 mg
Magnesium	10 mg
Potassium	133 mg
Sodium	2000 mg
Vitamins	
Thiamine	0.03-0.038 mg
Riboflavin	0.019-0.03 mg
Carotene	0.003-0.552 mg
Vitamin C	34 mg
Vitamin A	61 IU
Ascorbic acid	26.0-53.1 mg
Niacin	0.294-0.38 mg

Table IV: Phytochemical contents of *Averrhoa carambola* [36-41]

Phytoconstituents	**Plant Part**
Saponins, Alkaloids, Flavonoids	Fruit
Proanthocyanidins, epicatechin, Gallic acid in gallotannin	Fruit
Sterols- β sit sterol, campesterol, lupeolan disofucosterol	Fruit
Fatty acid- Palmitic, oleic, linoleic and linolenic acid	Fruit
Minerals- Iron, Calcium, Phosphorous	Edible portion of Fruit

Flavones- Apigeni-6-C-β-L fucopyranoside and apigenin-6C-β-1fucopyranoside	Fruit
Anisaldehyde, 5hydroxymethyl-2-furfur-al, Gallic acid and dihydroabscissic alcohol	Stem and bark
Lignins- Benzyl-1-*O*-*β*-*D*-glucopyranoside, (+) 5'methoxyisolariciresinol 3α-*O*-*β*-*D* glucopyranoside	Roots
Tannins	Fruit
Glycosides- 3,5-dimethoxy-4-hydroxyphenyl 1-*O*- *β*-apiofuranosyl (1"→6')-*O*-*β*-*D* glucopyranoside, (2*S*)-2-*O*-*β*-*D*-glucopyranosyl-2- hydroxyphenylacetic acid	Roots

Table V: Pharmacological aspects of *Averrhoa carambola* [42]

Pharmacological activity	Plant part	Extracts
Anti-inflammatory	Stem	Aqueous extract
Analgesic	Fruit	Fruit extract
Hypotensive	Leaves	Aqueous extract
Anthelmintic	Leaves	Aqueous extract
Anti-oxidant	Fruit	Juice and residue extract
Anti-ulcer	Leaves	Water alcohol extract
Hypocholesterolaemic and hypolipidemic	pomace	Water insoluble fiber rich fraction (WIFF)
Antimicrobial	Stem	Stem extract
Anti-tumor	Stem	Aqueous extract

Figure I. Leaf and flower measurement of eight varieties of carambola at the Germplasm Garden[58]

Variety	Leaf		Leaflet			Flower				
	Length	Wide	Length	Wide	Total	Length	Wide	No. of petal	No. of corolla	Pistil length
	(cm)	(cm)	(cm)	(cm)		(mm)	(mm)			(mm)
Dewimurni	23.6	15	7.4	4	5	6.3	3.5	5	5	2.7
Rawasari	23.3	15.3	7.8	3.3	5	6.1	3.7	5	5	2.5
Sembiring	25.8	17.2	8.8	3.4	4	4.8	2.8	5	5	3.0
Malaysia	21.7	15.9	7.7	3.8	5	4.6	3.2	5	5	2.9
Demak	20.6	13.7	6.8	3.3	5	4.6	3.7	5	5	2.7
Penang	23.3	15.6	7.8	3.2	5	5.0	3.3	5	5	2.9
Dewabaru	29.5	19.2	9.4	3.9	5	5.1	3.1	5	5	3.0
Bangkok	24.5	16.9	8.4	4.5	5	3.7	2.8	5	5	2.2
Average	24.0	16.1	8.0	3.7	4.9	5.0	3.2	5	5	2.7
Variance	7.4	2.8	0.7	0.2	0.1	0.7	0.1	0	0	0.1
Stand. Dev.	2.7	1.7	0.8	0.5	0.4	0.8	0.4	0	0	0.3

Figure II: Dendogram for carambola varieties based upon the morphology of leaves, flower and fruit[58]

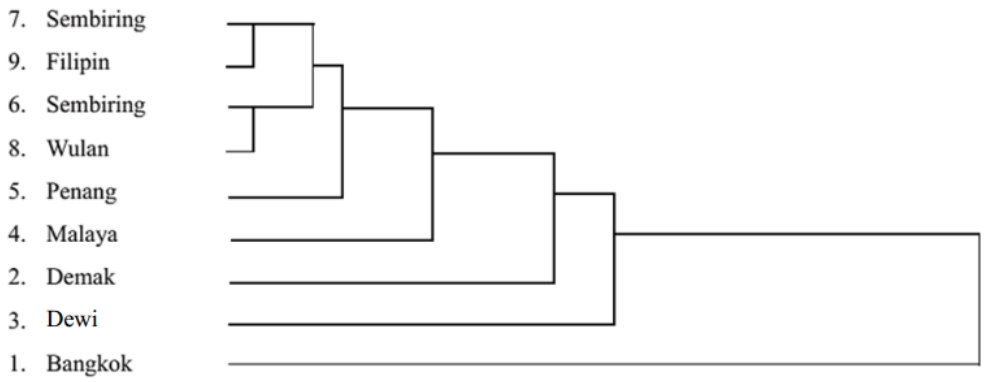

Figure III: Dendogram for carambola varieties based upon the RAPD analysis using UPGMA[58]

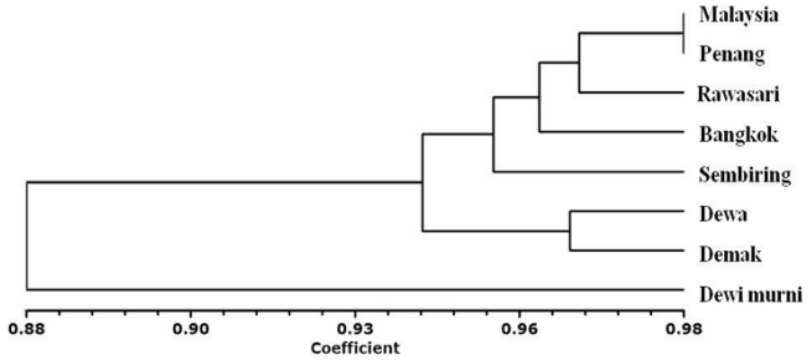

Table VII. Chemical composition of Products from Carambola fruit [59]

Parameters	Carambola Jam	Carambola Squash
Moisture (%)	28.5±0.01	57.20±0.02
Carbohydrate (%)	70.43±0.02	42.04±0.01
Protein (%)	0.45±0.01	0.29±0.01
Fat (%)	0.15±0.03	0.08±0.02
Ash (%)	0.47±0.01	0.47±0.01
Fiber (%)	1.14±0.04	0.08±0.01
PH	2.45±0.1	2.40±0.10
Acidity (%)	0.51±0.01	0.58±0.01
Total Soluble Solid (%)	68.4±0.02	40.7±0.03
Vitamin- C (mg\100g)	0.015±0.001	0.012±0.01
Energy (Kcal)	284.87±0.2	170.04±0.08

Triplicate analyses were performed and the results were expressed in g%
as mean values ± standard deviation

Table VIII. Storage Stability of Carambola Jam [59]

Day	Moisture (%)	TSS (%)	PH	Acidity (%)	Vitamin-C (mg\100g)
Temperature					
0 Days					
25-34°C	31.98±0.02	68.00±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
10°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
0°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
15 Days					
25-34°C	31.98±0.02	68.00±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
10°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
0°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
30 Days					
25-34°C	31.98±0.02	68.00±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
10°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
0°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
45 Days					
25-34°C	31.97±0.02	68.00±0.01	3.4±0.01	0.48±0.001	0.0056±0.001
10°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
0°C	31.98±0.01	68.02±0.01	3.5±0.01	0.47±0.001	0.0056±0.001
60 Days					
25-34°C	31.97±0.02	68.00±0.01	3.3±0.01	0.47±0.001	0.0056±0.001
10°C	31.98±0.01	68.02±0.01	3.4±0.01	0.47±0.001	0.0056±0.001
0°C	31.98±0.01	68.02±0.01	3.4±0.01	0.47±0.001	0.0056±0.001
75 Days					
25-34°C	31.96±0.02	68.02±0.01	3.3±0.01	0.47±0.001	0.0056±0.001
10°C	31.97±0.01	68.03±0.01	3.4±0.01	0.47±0.001	0.0056±0.001
0°C	31.97±0.01	68.03±0.01	3.4±0.01	0.47±0.001	0.0056±0.001
90 Days					
25-34°C	31.95±0.02	68.02±0.01	3.2±0.01	0.48±0.001	0.0056±0.001
10°C	31.96±0.01	68.04±0.01	3.3±0.01	0.47±0.001	0.0056±0.001
0°C	31.96±0.01	68.03±0.01	3.3±0.01	0.47±0.001	0.0056±0.001
105 Days					
25-34°C	31.94±0.02	68.03±0.01	3.1±0.01	0.49±0.001	0.0056±0.001
10°C	31.96±0.01	68.04±0.01	3.3±0.01	0.47±0.001	0.0055±0.001

0°C	31.95±0.01	68.04±0.01	3.3±0.01	0.47±0.001	0.0054±0.001
120 Days					
25-34°C	31.90±0.02	68.04±0.01	3.0±0.01	0.49±0.001	0.0056±0.001
10°C	31.94±0.01	68.05±0.01	3.3±0.01	0.47±0.001	0.0054±0.001
0°C	31.95±0.01	68.04±0.01	3.3±0.01	0.47±0.001	0.0053±0.001
135 Days					
25-34°C	31.88±0.02	68.05±0.01	3.0±0.01	0.50±0.001	0.0056±0.001
10°C	31.92±0.01	68.06±0.01	3.2±0.01	0.47±0.001	0.0054±0.001
0°C	31.91±0.01	68.05±0.01	3.3±0.01	0.47±0.001	0.0052±0.001
150 Days					
25-34°C	31.86±0.02	68.07±0.01	2.99±0.01	0.52±0.001	0.0055±0.001
10°C	31.90±0.01	68.06±0.01	3.2±0.01	0.48±0.001	0.0054±0.001
0°C	31.91±0.01	68.05±0.01	3.3±0.01	0.48±0.001	0.0051±0.001
165 Days					
25-34°C	31.85±0.02	68.10±0.01	2.98±0.01	0.55±0.001	0.0055±0.001
10°C	31.89±0.01	68.06±0.01	3.1±0.01	0.49±0.001	0.0054±0.001
0°C	31.89±0.01	68.05±0.01	3.3±0.01	0.49±0.001	0.0051±0.001
180 Days					
25-34°C	31.80±0.02	68.12±0.01	2.97±0.01	0.58±0.001	0.0053±0.001
10°C	31.85±0.01	68.08±0.01	3.1±0.01	0.52±0.001	0.0049±0.001
0°C	31.87±0.01	68.06±0.01	3.3±0.01	0.50±0.001	0.0045±0.001

Triplicate analyses were performed and the results were expressed in g% as mean values ± standard deviation

Table IX. Storage Stability of Carambola Squash [59]

Day	Moisture (%)	TSS (%)	PH	Acidity (%)	Vitamin-C (mg\100 g)
Temperature					
0 Days					
25-34°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
10°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
0°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
15 Days					
25-34°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
10°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
0°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
30 Days					
25-34°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
10°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
0°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
45 Days					
25-34°C	57.20±0.02	40.7±0.03	2.40±0.14	0.59±0.01	0.012±0.01
10°C	57.20±0.01	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
0°C	57.20±0.02	40.7±0.03	2.40±0.14	0.58±0.01	0.012±0.01
60 Days					
25-34°C	57.18±0.02	47.5±0.03	2.40±0.14	0.60±0.01	0.012±0.01
10°C	57.19±0.02	40.6±0.03	2.40±0.14	0.59±0.01	0.011±0.01
0°C	57.19±0.01	40.6±0.03	2.40±0.14	0.59±0.01	0.011±0.01
75 Days					
25-34°C	57.18±0.02	40.7±0.03	2.39±0.14	0.62±0.01	0.012±0.01
10°C	57.18±0.02	40.9±0.03	2.40±0.14	0.60±0.01	0.011±0.01
0°C	57.18±0.01	40.9±0.03	2.39±0.14	0.60±0.01	0.011±0.01
90 Days					
25-34°C	57.18±0.02	40.7±0.03	2.39±0.14	0.64±0.01	0.012±0.01
10°C	57.18±0.02	40.9±0.03	2.40±0.14	0.61±0.01	0.011±0.01
0°C	57.18±0.01	40.9±0.03	2.39±0.14	0.61±0.01	0.011±0.01
105 Days					
25-34°C	57.15±0.03	40.8±0.03	2.33±0.12	0.64±0.01	0.012±0.01
10°C	57.16±0.01	41.0±0.01	2.39±0.10	0.61±0.01	0.012±0.01
0°C	57.17±0.02	41.0±0.01	2.39±0.10	0.61±0.01	0.010±0.01
120 Days					
25-34°C	57.13±0.03	40.9±0.03	2.30±0.12	0.65±0.01	0.012±0.01
10°C	57.14±0.01	41.0±0.01	2.38±0.10	0.61±0.01	0.012±0.01
0°C	57.12±0.02	41.1±0.01	2.37±0.10	0.61±0.01	0.010±0.01
135 Days					
25-34°C	57.10±0.03	40.9±0.03	2.26±0.12	0.67±0.01	0.012±0.01
10°C	57.11±0.01	41.1±0.01	2.35±0.10	0.62±0.01	0.012±0.01

0°C	57.12±0.02	41.2±0.01	2.34±0.10	0.62±0.01	0.010±0.01
150 Days					
25-34°C	25-34°C	25-34°C	25-34°C	25-34°C	25-34°C
10°C	10°C	10°C	10°C	10°C	10°C
0°C	0°C	0°C	0°C	0°C	0°C
165 Days					
25-34°C	25-34°C	25-34°C	25-34°C	25-34°C	25-34°C
10°C	10°C	10°C	10°C	10°C	10°C
0°C	0°C	0°C	0°C	0°C	0°C
180 Days					
25-34°C	25-34°C	25-34°C	25-34°C	25-34°C	25-34°C
10°C	10°C	10°C	10°C	10°C	10°C
0°C	0°C	0°C	0°C	0°C	0°C

Triplicate analyses were performed and the results were expressed in g% as mean values ± standard deviation.

Table X: physical analysis of star fruit[61]

parameter	Observations	
	Unripened fruit	**Ripened fruit**
Fresh weight (gm)	26.77 gm	68.99 gm
Dry weight (gm)	1.77 gm	2.78 gm
Moisture content %	88.6%	91.7%
Total solids (gm)	0.042 gm	0.036 gm
pH	4.09	5.04

Table XI: Chemical evaluation of star fruit[61]

Parameter	Observations	
	Unripened fruit	**Ripe fruit**
Total protein content	31gm%	92gm%
Reducing sugars content	0.947gm%	1.122gm%
Total sugar content	1.25gm%	1.69gm%
Ascorbic acid content	39.50gm%	28.66gm%

Table XII: Rf of standard sugars and unknown sugars of the star fruit juice[61]

Sugar sample	R_{f*}
Lactose	0.26
Glucose	0.50
Fructose	0.53
Maltose	0.32
Sucrose	0.46
Unripened fruit juice (Sample 1)	0.46
Ripened fruit juice (Sample 2)	0.47

Table XIII: alcohol production from the fruit[61]

Parameter	Observation	
	Unripened fruit	**Ripe fruit**
Juice+ 10gm sugar+ yeast culture	0.98mg/ml	1.54mg/ml
Juice+ yeast culture	1.05 mg/ml	1.58 mg/ml
Juice+ 10gm sugar	0.35 mg/ml	0.76 mg/ml
Juice	0.36mg/ml	0.41 mg/ml

