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REVIEW ARTICLE

Therapeutic Properties of *Averrhoa carambola* L and Its Utilization in Development of Value-added Food Products

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Abstract

Carambola commonly known as star fruit, is the fruit of *Averrhoa carambola*, a species of tree native to tropical Southeast Asia. It has numerous potential health benefits and is considered as a nutritionally rich fruit. This paper provides a brief overview of the origin, taxonomy and distribution of *Averrhea carambola* L fruit in India and abroad. The nutritive value specifically the proximate composition, macronutrient micronutrients composition and bioactive compounds are also elaborately discussed. Medicinal properties of *Averrhea carambola* L fruit in terms of its anticancer, anti-inflammatory, antioxidant, hypoglycemic, hypolipidemic, hepatoprotective, cardioprotective activity is also briefly discussed. Value addition being a very important method of income generation and entrepreneurship development, how value-added foods can be developed using *Averrhea carambola* L fruit and scope and prospects of value addition of the fruit is also reviewed in this chapter.

Keywords: *Carambola, Therapeutic, Value-Addition, Medicinal, Nutraceutical*

1 Introduction

Averrhoa carambola, also known as star fruit is a commonly consumed fruit in both tropical and other countries. It is cultivated in many parts of the world mostly in South East Asian regions. Star fruit has several nutritional and medicinal uses and is considered a rich source of natural antioxidants and minerals(1) . The word carambola was taken from the Sanskrit word karmaranga which means 'food appetizer'. In different countries, carambola is known under different names. Some of the local names are: in Bengali, it is known as "kamranga", in Assamese "kordoi"/ "rohdoi", in Marathi "karambal", in Telugu "ambanamkaya", in Hindi and Gujarati as "kamrakh", in Tamil "thambaratham" and in English "carambola" or "starfruit"(2). The star-fruit plant *Averrhoa carambola* L. is the member of the Oxalidaceae family, it is a medium-sized tree that is classified by its unique, attractive star-shaped fruit. Star fruits have a distinctive taste, with a bit tart, acidic taste specially in smaller fruits or sweet and mild flavor in large fruits(3). This Star-fruit plant allied to the genus Averrhoa, contains 5 species, namely A. bilimbi, A. dolichocarpa, A. leucopetala, A. microphylla and A. carambola(4). Star-fruit is known to possess therapeutic effects according to pharmacological assays which include anti-inflammatory, antimicrobial, antifungal, antitumor, anti-ulcer, hypocholesterolemic, hypoglycemic and hypotensive effects. Star-fruit is also known for its richness in phenolics including flavonoid C-glycosides like carambolaflavone and carambolaside M with regard to its chemical composition. Additionally, alkaloids of the tetrahydroisoquinoline group such as (1R*,3S*)-1-(5-hydroxymethylfuran-2-yl)-3-carboxy-6-hydroxy-8-methoxyl-1,2,3,4 tetrahydroisoquinoline were isolated from starfruit(5). Therefore, the current review aims to highlight the therapeutic importance of starfruit and its potentiality as value added products.

Table 1: Taxonomic Classification of Starfruit Plant

Taxonomy	Classification
Kingdom	Plantae
Sub-kingdom	Tracheobionta
Super-division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Sub-class	Rosidae
Order	Geraniales
Family	Oxalidaceae
Genus	Averrhoa Adans.
Species	*Averrhoa carambola* L.

2 Origin and Distribution in India and Abroad

Believed to have originated in Ceylon and the Moluccas (Indonesian islands), the carambola has been cultivated in Southeast Asia and Malaysia for many centuries and is commonly found in Sri Lanka, Southern China, Taiwan, Philippines, Queensland, Australia, Malaysia, Thailand, Israel, Florida, Brazil, Indonesia, Tahiti, in the South Pacific islands(6; 7) [6,7]. In the provinces of Fukien, Kuangtung and Kuangsi in southern China, in Taiwan and India, starfruit is commonly grown and is popular in the New Caledonia, Netherlands, New Guinea, Guam and Hawaii.
In the Caribbean islands, Central America, tropical South America, in West Tropical Africa and Zanzibar, there are some specimens of the tree in special collections. Since 1935, several trees have been growing at the Rehovoth Research Station in Israel and it is grown more as an ornamental than for its fruits in many areas(2).

3 Traditional Uses of Starfruit

Star fruit may be eaten in raw form or used in the preparation of juices, salads or pickles. In several countries, it is considered as an herb(1; 8). The fruits are green when small and unripe but turn to yellow or orange when matured and ripe. The fruits are fleshy with an oblong shape, crunchy, having a crisp texture and form star shape when cut in cross section(9). Two main types of taste- sweet and sour are exhibited by the fruit with a complicated flavour combination that includes plum, pineapple and lemon notes. By being both sweet and juicy, the mature fruit taste is characterized. Widely used in Asian foods, the fruit juice is also considered a popular thirst-quencher(5). In Ayurveda, to pacify impaired kapha, pitta, skin diseases, pruritis, worm infestations, diarrhea, vomiting, hemorrhoids, intermittent fever, over-perspiration and general debility, preparations of starfruit and its leaves are used. The ripe fruits or its juice are used as anti-pyretic, laxative, appetite stimulant, sialogogue, astringent and antiscorbutic in India. In kidney and bladder related problems, the fruit is recommended as diuretic in Brazil(10). Being popular tropical fruits, starfruits are commonly used in Ayurvedic and Traditional Chinese Medicines (TCM) in India, China and Brazil to relieve ailments such as chronic headache, fever, cough, gastro-enteritis, diarrhoea, ringworm infections and inflammation of skin(4). The ripe fruit is considered as digestive, tonic and causes biliousness in Ayurveda. Moreover, to treat throat inflammation, mouth ulcer, toothache, cough, asthma, hiccups, indigestion, food poisoning, colic, diarrhea, jaundice, malarial splenomegaly, hemorrhoids, skin rashes, pruritis, sunstroke and some eye related problems, the fruits are used. For both men and women, they are used as aphrodisiac(10). Carambolas, when ripe, are eaten as fresh fruit, as salads, or used as a garnish to avocado or fish dishes. These fruits are cooked by Asian populations in different ways, jams, sauces, sausages and cakes. Malaysian populations consume it by preparing a sauce in which the fruit is boiled with sugar, cloves, and apples; the fruit is cooked with fish by the Chinese and the unripe fruit is boiled with shrimp by the Thais(6).

4 Nutraceuticals Nutritive Value of Starfruit

4.1 Proximate Composition

Averrhoa carambola L., well known as Starfruit or carambola, is a woody tree-bearing crunchy fruit that has a slightly tart, acidic sweet taste(11). It is cultivated worldwide and is one of the most commonly consumed fruit in both tropical and other countries(1). Two major classes of carambola are seen: smaller with a sour taste and larger with a sweet taste. The term carambola is derived from the Sanskrit word Karmaranga meaning 'food appetizer'(7). Star fruits are rich in natural antioxidants such as vitamin C, -carotene, gallic acid, and fiber. It is a good source of magnesium, iron, zinc, manganese, potassium, and phosphorous and has low calories(1).
Consumption of carambola when drinking alcohol is also found to be beneficial as it lowers the concentration of ethanol in the blood which has a direct toxic effect on the hepatocyte, and also induces degeneration and damage to the brain by impairing the blood-brain barrier as a result of drinking alcohol(12). Starfruit is rich in fiber and low in calories. High amounts of fiber in starfruit contribute to beneficial effects on glucose homeostasis and help decrease the incidence of colorectal cancer(5). Also, the presence of insoluble fibers in the fruit helps in inhibiting the activity of -amylase and delays the release of glucose from starch(1). Carambola is also low in calories making it a very good choice for diabetic patients(5). Phytosterols present

Table 2: Proximate Composition of Star Fruit

Nutrients	**Value per 100mg**
Moisture	89000-91000 mg
Ash	0.26-0.40 mg
Fiber	0.80-0.90
Carbohydrate	9380 mg
Protein	380 mg
Fat	80 mg
Calories	35.7

Table 3: Mineral Contents of Starfruit

Mineral	**Amount (mg/100g fruit) ***
Sodium (Na)	3.8 - 3.85
Potassium (K)	167.13 - 168.0
Calcium (Ca)	6.37 - 6.40
Phosphorous (P)	17.87 - 17.88
Magnesium (Mg)	11.85 - 12.05
Iron (Fe)	0.34 - 0.45
Copper (Cu)	0.19 - 0.45
Zinc (Zn)	0.29 - 0.51
Manganese (Mn)	0.04 - 0.52
Selenium (Se)	Not Detectable

*On a dry weight basis

Table 4: Carotene, Vitamins and Acids Found in Mature Star Fruits

Name	**Amount (mg/100g Star-fruit weight) ***
Carotene	0.003 - 0.55
Tartaric acid	4.37
Oxalic acid	9.6
Ketoglutaric acid	2.2
Citric acid	1.32
Vitamin B1 & B2	0.12
Vitamin C	25.8

*On a dry weight basis

in carambola are shown to mediate the decrease in lipid peroxidation(13).

Carambola is a good source of minerals and electrolytes like potassium, phosphorus, and magnesium which are common antioxidants and helps to strengthen the immune system(4) and are also helpful in the prevention of cancer. Starfruit also helps in lowering cholesterol, jaundice, and constipation(14). Potassium is seen to be beneficial in controlling heart rate and blood pressure; thus, countering the bad influences of sodium(15).

Starfruit being an excellent source of ascorbic acid, could suppress glycation and reduce glycohemoglobin in all proteins of aged individuals and it is also beneficial in decreasing osmotic fragility of erythrocytes from oxidative stress(16). Saponins, flavonoids, alkaloids, and tannins present in starfruit extract confer antioxidant and specific healing properties(6). Extracts of starfruit are also found to have antimicrobial activity being effective against Escherichia coli, Pseudomonas aeruginosa, and Bacillus cereus making it a wonderful choice of fruit for individuals of all age groups(4).

4.2 Bioactive Compounds in Star Fruit

Star fruit is considered a rich source of macro and micro nutrients as well as phytochemicals. The bioactive compound studies on the extracts of *Averrhoa carambola* plant leaves, fruits, and roots showed approximately 132 phytochemical compounds which contains flavonoids, terpenes, alkaloids, phenylpropanoids, and their glycosides, among others. Other phytochemicals such as phenols, anthocyanin and anthocyanidin, chalcones and aurones, leucoanthocyanidins, catechins, and triterpenoids were also extracted from various parts of star fruit(17). These compounds have been considered as the biologically active components responsible for multiple bioactivities(4; 18) [4, 19]. Antioxidant capacity values was reported in A. carambola L. of 1215.34 ±

101.98 µmol TE/g FW by DPPH and values of 3370.94 ± 308.02 µmol TE/g FW by FRAP(19). On the other hand, a higher antioxidant capacity was reported(20) in fresh matter by DPPH with 100 ± 6.2 IC50 µg/mL, and a lower antioxidant capacity using the TEAC technique with 0.37 ± 0.023. In contrast, they obtained a lower value of antioxidant capacity in dry matter by DPPH with 150 ± 3.4 IC50 µg/mL and a higher value by means of the TEAC technique with 1.05 ± 0.005. On the other hand, a higher antioxidant capacity was observed in microwave extracted starfruit sample. Because the phenolic chemicals included in the vegetal matrix of the juice of A. carambola L. are released when heated for a brief length of time, it is likely that the microwave extraction approach led to a general increase in antioxidant capacity(21). In contrast to the findings, antioxidant capacity values of 18.1 0.51 Mmol TE/g DM by ABTS and values of 4.61 0.70 Mmol TE/g DM by FRAP was recorded(22) . Antioxidant capacity values of 190 mol/L was obtained(23) when utilising the nitric oxide (NO) technique and values of 722.71 12.25 g GAE/g extract via ABTS. However, from collecting the sample to the type of analysis, each researcher employs a distinct methodology, which can account for the variations in their findings. Polyphenolic antioxidants were detected in star fruit using liquid chromatography and mass spectrometry. The main antioxidant action was attributed to phenolic compounds such as L-ascorbic acid, epicatechin, and gallic acid in gallotannin form(24). Another study(25) investigated total phenolic compounds (TPC) and total flavonoid content (TFC) in aqueous and methanolic extracts and found to be 58.8 ± 0.60 mg gallic acid equivalents (GAE)/g and 27.6 ± 0.13 mg catechin equivalents (CE)/g for aqueous extract. On the other hand, for the methanolic extract 142.0 ± 0.25 mg GAE/g of TPC and 79.7 ± 2.09 mg CE/g of TFC were obtained. In another study, A. carambola L. fruit was aqueously extracted and HPLC was used to determine the phenolic components. They reported various phenolic compound percentages: Vanillic acid: 2.41 0.52%; apigenin: 0.36 0.81%; kaempferol: 3.32 0.67%; luteolin: 1.39 0.80%; naringenin: 1.38 0.23%; and quercetin: 65.66 0.12%. Gallic acid: 1.96 0.59%; 4-hydroxycinnamic acid: 0.50 0.56%; 4-hydroxy-3 These authors also examined the phenolic profile in the ethanolic extract and reported the following values: chlorogenic acid 1.94 0.25%, gallic acid 6.47 0.37%, 4-hydroxycinnamic acid 3.59 0.43%, 4-hydroxy-3-methoxycinnamic 1.87 0.54%, vanillic acid 4.54 0.99%, kaempferol 4.25 0.41%, luteolina 11.40 They discover, generally, that the ethanolic extract contains more phenolic chemicals than the aqueous extract(26). Another study isolated thirteen flavonoids from the fresh sweet fruit of *Averrhoa carambola* L. Some of the compounds like 8- Carboxymethyl-(+)-epicatechin methyl ester, pinobanksin 3-O--D-glucoside, and carambolasides M–Q, (+)-Epicatechin, aromadendrin 3-O--D-glucoside, helicioside A, taxifolin 3-O--Dglucoside, galangin 3-O-rutinoside, and isorhamnetin 3-O-rutinoside were reported from this species for the first time by the researchers(27). Another bioactive compound which proved to significantly enhance the flavour of A. carambola fruits is the terpenes-derived components from star fruits primarily C13- and C15-norisoprenoids(28). NMR and MS was used to analyse different terpenes in star fruits, and the main terpenes found were cis-abscisic acid, trans-abscisic acid, trans-abscisic alcohol, (6S, 9R)-vomifoliol and cis-abscisic acid –D(29). In another bioactive study, it was revealed that star fruit meet the standards of Indonesian Herbal Pharmacopoeia with highest apigenin (6.37%) and quercetin (4.49%) content are in ethyl acetate fraction. A good amount of antioxidant activity of star fruit residues was reported. The major bioactive substances were also identified and quantified, and several of them were found in residues, including catechin, cyanidin 3-glucoside, epicatechin, galangin, gallic acid, homogentisic acid, kaempferol, and chlorogenic acid(30). This proves that star fruit residues can also be an inexpensive and readily available resource of bioactive compounds for use in the food and pharmaceutical industries.

5 Medicinal Properties of Star Fruit

A. carambola L. (Star fruit) has been used as traditional medicine for various purposes such as to treat stomach ulcers, relieve digestive related problem, cure cough, cold, fever, cease hemorrhage and bleeding hemorrhoids; also, home remedy for hangovers and sunburns. They are considered to possess various health beneficial effects including antioxidant, hypoglycemic, hepatoprotective, hypocholesterolemic, anti-inflammatory, antitumor effects(7).

5.1 Antioxidant Activity

Star fruit reported to exhibits high antioxidant activity and has the ability to scavenge reactive oxygen species (ROS) and free radicals. A comparative study was demonstrated on antioxidant properties based on assays against FRAP and DPPH activities, total flavonoid content, total phenolic content, and vitamin C content on locally available fruits in Sri Lanka, they showed that A. carambola is one of the most potent antioxidant activities among all the fruits(31). Another comparative study showed that nearly 6.93 ± 0.25 IC50 mg/mL by DPPH was seen in A. carambola L. along with 28.41 ± 5.31% by the -Carotene bleaching assay depicting higher results than the variety of A. bilimbi L.(32). Moreover, significantly high value of DPPH and FRAP value of A. carambola L. was showed in a study i.e., 1215.34 ± 101.98 µmol TE/g FW and 3370.94 ± 308.02 µmol TE/g FW, respectively(19). DPPH assay of A. carambola L. was evaluated(31) [35] with the values of 0.6 IC50 mg/mL showing a high antioxidant activity. A. carambola L. contains high concentrations of total phenolic compounds and total flavonoid compounds, which contribute to exhibit high antioxidant capacity. The phenolic compounds present in A. carambola L. are gallic acid, kaempferol, luteolin, naringenin, morine, quercetin, myricetin, catechin, vanillic acid, caffeic acid, chlorogenic acid, p-cumaric acid, ellagic acid, 4-hydroxycinnamic acid, protocatechuic acid, p-hydroxybenzoic acid, syringic acid, epicatechin, proanthocyanidins etc.(33; 34).

5.2 Anti-Inflammatory Activity

Inflammation is a physiological process for repairing tissue in response to endogenous or exogenous stimulus during the aging process, leads to increases in secretion of cytokines i.e., tumor necrosis factor-alpha (TNF-), interleukin-6 (IL-6), Interleukin-1 (IL-1), C-reactive protein (CRP)(35). A

study was conducted(16) to evaluate the effect of star fruit juice supplementation on cytokines secretion in 29 elderly individuals. Results revealed that consumption of star fruit juice at 100 g twice daily for 6 weeks can significantly depress the pro-inflammation cytokines tumor necrosis factor-alpha (TNF-) and interleukin-23 (IL-23). The polysaccharide extracted from the fruit of A. carambola reduced intraplantar formalin-injected paw edema in adult female Swiss mice with the doses of 100 and 300 mg/kg at 53% inhibition rate, showing antiinflammatory properties(36). Similar study was reported on reduction of ear edema in croton oil-induced mouse with the doses of 0.03–1.0 mg/ear of ethanol extract of A. carambola leaves with IC50 value of 0.05, moreover, suppressed myeloperoxidase (MPO) activity(37).

5.3 Anti-Tumor Effects

Several literatures have claimed anti-tumor effects of different parts of A. carambola such leaves, roots and fruits. The prophylactic role of A. carambola extract against induced hepatocellular carcinoma in Swiss albino mice showed positive effects by reduction in tumor incidence, tumor yield, and tumor burden as compared to a control group [2014]. Another study reported(38) on the tumor-targeted 2-dodecyl-6-methoxycyclohexa-2,5-diene-1,4-dione (DMDD isolated from A. carambola L. roots) liposomes (HA/TN-DLP) were conducted and assessed. HA/TN-DLP inhibited the glycerophospholipid metabolism pathway through regulating the expressions of CEPT1 and LYPLA1, and inhibited tumor cell growth by regulating the PI3K/Akt and NF-B signaling pathways. It can be concluded that HA/TN-DLP may be a promising tumor-targeting agent. Similar study revealed that antineoplastic effect of A. carambola L. leaf against Ehrlich Ascites Carcinoma (EAC) cell bearing mice. Results has showed that the viable tumor cell count was reducing, increases survival time and body weight; also revive the altered hematological (Hb, total RBC and WBC) parameters compare to those with normal values, indicating leaf of *Averrhoa carambola* exhibited potent antineoplastic and apoptotic activities(39).

5.4 Hypoglycemic Activity

Effective role of natural source treatment as anti hyperglycemic can be determined by its ability to adsorb glucose, interfere glucose diffusion, lower the glucose release from starch and inhibit the activity of -amylase enzyme. *Averrhoa carambola* fruit has hypoglycemic activity and the ability to control blood glucose level as its insoluble fiber rich fraction contain substantially (P<0.05) stronger hypoglycemic effect than those of cellulose(40). Hypoglycemic potential of different parts of carambola can be used to treat diabetic patient in the future. Extract of carambola roots possess the anti hyperglycemic effect which could decrease the blood glucose serum level, protect the pancreatic cells in STZ induced diabetic rats(41). In vitro studies revealed the leaves of carambola could lower the serum glucose level significantly as same as the standard anti hyperglycemic drug, glibenclamide. Carambola can be assigned as natural source of digestive enzyme inhibitor. Reduction of postprandial hyperglycemia is another attribute as potent mechanism and the fruit pulp of carambola contains flavonoids, phenols which acts a hypoglycemic factor and delays the glucose absorption42. Flavonoids such as apigenin-6-C--fucopyranoside (1) isolated from the leaves of carambola significantly agrees the potent behavior as having hypoglycemic factor(43).

5.5 Hypolipidemic Effect

Another explored role of A. carambola is having potent anti hyperlipidemic activity. The leaves of carambola behaving as hypolipidemic can be related to various mechanism such as its ability to inhibit HMG-CoA reductase, promoting increased secretion of cholesterol and bile acids in the feces, and reduction of TC and TG levels in the liver. In vitro study revealed the reduction of serum lipids and at 1000mg/kg dose restored the hepatic tissue damage(44; 41). This activity of carambola can be supported by another investigation of benzoquinone of *Averrhoa carambola* L. root on STZ model where the attenuated level of total cholesterol (TC), triglyceride (TG) and low-density lipoprotein cholesterol (LDL-C), high-density lipooprotein cholesterol in serum as well as MDA in liver markedly decreased(45). Also, another study reported(46) the hypolipidemic effect of water-insoluble fiber rich fraction (WIFF) from the pomace of star fruit, in vitro results showed while administration of WIFF diet lowered the serum level and total cholesterol and increased concentrations of fecal total lipids, fecal cholesterol and bile acids. The ability to enhance the excretion of cholesterol and bile acids via feces can be one of the attributes of carambola possessing antihyperlipdemic effect. Other prospects of hypolipidemia effect can be assigned to the availability of pectin which can reduce the blood cholesterol level. Report acknowledges that administration of pectin ameliorated the lipid profile and could increase viscosity in intestinal tract(47). Study ascertain *Averrhoa carambola* fruit extract protect against hyperlipidemia- induced liver damage in rats and the increased serum profile and degradation of liver histology was improved(48).

5.6 Hepatoprotective Activity

Averrhoea carambola also possess hepatoprotective effect against carbon tetrachloride induced hepatic injury. Usually, hepatic injury is determined by increased serum level and decrease liver gluthathione level. Studies revealed the fruit extract of *Averrhoa carambola* administered in hepatotoxicity induced rats improved the serum profile ALT, AST and ALP enzyme and significantly increased gluthathione level after 24h of administration of CCL4(49). H_2O_2 induced oxidative damage in human hepatocellular cells is another reason for hepatic damage. The high phenolic content of starfruit assessed the antioxidant activity which showed protective effect against liver cytotoxicity(50). Averrhoea carambola also has potential to prevent DENA/CCl4 induce physical and biochemical changes during hepatocellular carcinoma (HCC). Another investigation(13) revealed treatment with Averrhoea carambola extract reduced peroxidation of lipid and increased the activities of Reduced Glutathione (GSH), Catalase (CAT) and Superoxide Dismutase (SOD) in mice during hepatic carcinogenesis.

5.7 Cardioprotective Effect

Ventricular remodeling (VR) is associated with changes in endothelial vasoactive substances, cardiomyocyte hyper-

trophy, myocardial fibrosis, and endothelial dysfunction. An investigation was conducted of the protective property of the aqueous extract of A. carambola (AEAC) on isoprenaline-stimulated endothelial function in rats with VR, AEAC (at daily doses of 50, 100, and 200 mg/kg, i.g. for 14 days), which glaringly lowered iNOS, TGF-, Ang II, ECE, and ET-1 serum levels and their protein expressions and decreased the VR index and CVF but serum tNOS and eNOS levels and their protein expressions markedly elevated. It was demonstrated by pathological evaluations that AEAC radically alleviated inflammatory infiltration, apoptosis, fibrosis, and necrosis in rat myocardial tissues, which suggested that AEAC is possibly associated with safeguarding the balance of vasoactive components and vascular endothelium function as it potentially mitigated the VR of rats(51). A secondary metabolite of *Averrhoa carambola* leaves is the C-glycoside flavone, apigenin (also known as carambola flavone) by suppressing calcium influx through both voltage- and receptor-operated calcium channels relaxes rat thoracic aorta(1). It has been suggested that extracts of star fruit *Averrhoa carambola*, stinking nightshade (Hyoscyamus niger), and Ginkgo biloba inhibit cardiac calcium current according to studies conducted on analyzing effects of plant derived flavonoid extracts(52).

6 Value Addition

A study was conducted(53) to determine the effect of starfruit and papaya counterweight on the quality of the organoleptic properties, vitamin C and fiber in jelly. The basic ingredients starfruit and papaya was used to enrich the nutritional value of jelly candy, particularly vitamin C and fiber in which the counterweight was 25%:75%, 50%:50% and 75%:25%. The study results revealed that the proportion starfruit and papaya 50%:50% was found to be most accepted in terms of organoleptic properties of color, flavor, and aroma according to panelist assessment. Based on analysis results, vitamin C content was higher on counterweight starfruit and papaya (25%:75%) and fiber content was higher on counterweight starfruit and papaya (75%:25%). Another study was conducted utilizing a 23 central composite design to evaluate the production of a star fruit alcoholic fermented beverage utilizing a lyophilized commercial yeast (Saccharomyces cerevisiae). Initial soluble solids between 23.8 and 25 Brix (g 100 g-1), initial pH between 4.8 and 5.0 and initial concentration of yeast between 1.6 and 2.5 g L-1 were the best conditions for the production which yielded a fermented drink presenting low levels of total and volatile acidities(54). In another study(55), beers were prepared by fortification of star fruit juice at 5.0%, 7.0%, and 10% level and compared with control which were further assayed for proximate, physicochemical, bioactive and sensory properties. A nonsignificant ($p \leq .05$) effect on density and specific gravity was observed on addition of starfruit juice, whereas, there was increase in total soluble solids but decrease in pH, alcohol, and carbon dioxide content; a significant ($p \leq .05$) increment was observed in total phenolic content and antioxidant activity. In total, the highest overall acceptability was seen in 10% star fruit fortified beer. A study was conducted(56) to develop mixed cordial from star fruit and sweet orange. For the formulation of 100 ml of cordial, star fruit juice in the amounts of 80, 70 and 60 ml were mixed with sweet orange juice. After formulation and during storage, the cordials were subjected to nutritional, microbial and sensory analysis. The nutritional analysis of the developed cordials revealed that with an increase in the level of sweet orange juice. titrable acidity, ascorbic acid and total sugar increased. There were declining trends in ascorbic acid, pH and total sugar during the storage period and increasing trend in titrable acidity. The mixed cordial of 70% star fruit juice with 30% sweet orange juice was selected as best mixed cordial based on the assessment results. Another study was conducted to elaborate and characterize star fruit jam formulations with different contents of chilli pepper, in addition to verifying consumer acceptance. With variation in the concentration of chilli pepper, three samples of star fruit jam were formulated and subjected to physicochemical characteristics of moisture, pH, titratable acidity and soluble solids. In addition to sensory acceptance with an approval rate above 75% of the product, the developed jams showed good physical-chemical characteristics and acidic pH(57).

7 Conclusion

Popular around the world, the star fruit *Averrhoa carambola* is thought to provide a variety of healthful nutritional and therapeutic benefits. The high antioxidant potential of *Averrhoa carambola* fruit can be beneficial in preventing oxidative damage in cells and related diseases. Also, the plant has a wealth of secondary metabolites and phytochemicals, making it a potential source for high-value phytochemicals and their use in the pharmaceutical and nutraceutical industries. The highly nutritious underutilized fruit crop has proved to be an excellent choice for food product development as well. However, further investigations are required to establish the therapeutic potential of different parts of the plant.

Conflict of Interest

The authors declare no conflict of Interest in this reported communication.

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