Doi: HTTPS://DOI.ORG/10.23910/IJBSM/2017.8.4.1808b

Study on Antioxidant Potential and Nutrition Status of Different Underutilized Fruits in South Gujarat

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Article History

Article ID: AR1808b
Received in 15th April, 2017
Received in revised form 27th June, 2017
Accepted in final form 5th August, 2017

Abstract

A survey experiment was carried out at in department of Soil Science and Agricultural Chemistry, N. M. College of Agriculture during 2015–2016 to determine antioxidant and biochemical potentials in some underutilized fruit crops of South Gujarat region. The experiment was undertaken in above mentioned minor fruits, which were collected from local cultivar of South Gujarat includes the districts of Navsari, Surat, Bharuch, Valsad, Tapi, Narmada and Dang. Amongst all the analyzed fruits, *Emblica officinalis* L. fruits was found to possess highest antioxidant content (31.35%) followed by *Artocarpus heterophyllus* L. (25.18%) and *Zizyphus mauritiana* L. (15.46%), *Tamarindus indica* L. (8.50%). The antioxidant contents viz., ascorbic acid63.57 mg 100 g^{-1}, total phenol 31.06 GAE 100 g^{-1}, antioxidant enzymes like catalase (CAT) 33.38 U g-l fresh weight, superoxide dismutase (SOD) 2.98 U g^{-1} fresh weight and peroxidase (POD) 9.79 U g^{-1} fresh weight and antioxidant activity 74.18 µg.m^{l-1} was reported higher in *Emblica officinalis* L. fruits collected Navsari, Pardi and Gandevi grown fruits of South Gujarat. Maximum content of biochemical parameters was obtained in *Tamarindus indica* L. (13.7071%) fruits followed by *Zizyphus mauritiana* L. (12.52%) and *Artocarpus heterophyllus* L. (8.127%) fruits. The Biochemical contents viz., Total soluble solid (TSS) 40.07 °Brix, Total fat 0.61 g 100 g^{-1}, total carotenoids 22.00 µg 100 g^{-1}, reducing sugar 18.09 g 100 g^{-1}, soluble sugar 19.79 g 100 g^{-1}, protein 3.02 g 100 g^{-1} and acidity 12.17 was reported higher in *Tamarindus indica* L. collected from different places of South Gujarat. The consumption of these fruits as food supplements, their cultivation, conservation by the native tribal farming community should be encouraged in south Gujarat region.

Keywords: Ascorbic acid, antioxidant activity, total phenol, antioxidant enzymes

1. Introduction

Minor fruits are cultivated in lesser area compared to major fruits. This restricted cultivated fruits are also not abundant in market and usually are not cultivated in organised way. There are mainly four fruits come under the category of minor fruits, namely amla (*Emblica officinalis* L.), jackfruit (*Artocarpus heterophyllus* L.), tamarind (*Tamarindus indica* L.) and jujube (*Zizyphus mauritiana* L.) in the regions of south Gujarat (Hegde, 2009). Agro Industries Foundation has promoted the cultivation of these species on degraded hilly terrains in the Western Ghats region. Usually these tree plantations are maintained in local scale by the native user specially the tribal community of the South Gujarat for the fruits and the forest by products. Amla (*Emblica officinalis* L.) is one of the most celebrating plants in Indian traditional medicine, *Ayurveda* and are excellent source of various antioxidants. It is richest source of ascorbic acid (Khurana et al., 1970). An experiments conducted with the fruit of amla have been shown to possess antioxidant (Sultana et al., 2008) antibacterial and anti HIV (Eldeen et al., 2010). The use of herbal medicines in an evidence or science-based approach for the treatment and prevention of disease is known as phytotherapy. They are useful in vitiated conditions of tridosha, diabetes, cough, asthma, bronchitis, dyspepsia, colic, flatulence, hyperacidity, peptic ulcer, erysipelas, skin diseases, leprosy, haematogenesis, inflammations, anemia, emaciation, hepatopathy, jaundice, strangury, diarrhea, dysentery, hemorrhages, leucorrhoea, Menorrhagia, cardiac disorders, intermittent fevers and greyness of hair (Khurana et al., 1970) Jackfruit is an good source of antioxidants like Vitamin C, which helps to protect against viral and bacterial infections as well as strengthen the immune system function by supporting the white blood cells function. In addition to vitamin C, jackfruit is also rich in phyto-nutrients such as phenolics, flavonodies, *lisoflavones* which have anti-cancer and anti-aging properties. These phyto-nutrients may help to eliminate cancer causing free radicals from the body and

slowing down the degeneration of cells that can lead to degenerative diseases (Priya et al., 2014). Tamarind has many valuable antioxidant properties and virtually every part of the tree has been utilized by both rural and urban dwellers. The most valuable and commonly used part of the tamarind tree is the fruit. The pulp constitutes 30% to 50% of the ripe fruit, the shell and fibre account for 11% to 30% and the seed about 25% to 40% (Shankaracharya, 1980). The jujube fruits have emollient and expectorant antioxidants properties (Kirtikar et al., 1935) The fruit is also considered to be cooling and an anodyne and a tonic. It employed as an antidote to aconite poisoning and is recommended in nausea and vomiting. The fruits are applied on cuts and ulcers; are employed in pulmonary ailments and fevers and mixed with salt and chili peppers are given in indigestion and Biliousness. There is some evidence suggesting that fruits and their products have protective effects against cancer, stroke and coronary heart diseases, which may relate to the presence of some biologically active compounds present in it (Kalt et al., 1999)

The present survey experiment had been under taken to explore the antioxidant and nutritional potentiality of the four types of fruits from the different places of South Gujarat and extend their cultivation to uplift the livelihood of the local people.

2. Materials and Methods

2.1. Experimental site

The present study was conducted at the Department of Soil Science and Agricultural Chemistry, N. M. College of Agricultural, Navsari Agricultural University, Navsari. during 2015-16. The fresh fruit samples of Amla (*Emblica officinalis* L.), Jackfruit (*Artocarpus heterophyllus* L.), Tamarind (*Tamarindus indica* L.) and Indian jujube (*Zizyphus mauritiana* L.) for experiment collected from local cultivar of South Gujarat includes the districts of Navsari, Surat, Bharuch, Valsad, Tapi, Narmada and Dang.

2.2. Sample collection

Fruits sample collected from Different places of South Gujarat such as Amla fruits collected from Navsari, Pardi, Karadi, Tapi, Hasapur and Gandevi, Jackfruit fruits collected from Navsari, Karadi, Hasapur, Bardoli, Songadh and Valsad, Tamarind fruits collected from Navsari, Dharampur, Valsad, Pardi, Chikhli and Dang and Indian jujube fruits collected from Navsari, Vyara, Dang, Dungri, Bardoli, and Aat

2.2.1. Sampling material : fresh and dry powdered fruit

2.2.2. Time of harvesting : edible maturity stage

2.2.3. Sample preparation

Fresh fruits at edible maturity stage were harvested from different plants and were subjected to different types of chemical analysis.

2.3. Antioxidant parameters

Ascorbic acid (vitamin-C) was determined by the dichloro phenol indophenols (DCPIP) titration procedure Casanas et al. (2002). The phenol content in the fresh tissue extract was measured by the Folin-Ciocalteau reagent using catechol by using Vinson et al., 2001 method. Catalase activity was estimated following the method of (Kar and Misra, 1976). The assay was based on the capacity of extracts to inhibit photochemical reduction of Nitro Blue Tetrazolium (NBT) in the riboflavin light- NBT system (Beauchamp and Fridovich, 1971). The method of Shanon (1966) was followed for analysis of peroxidase activity. The total antioxidant activity was determined using the 1, 1- diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging assay (Koleva et al., 2002).

2.4. Biochemical parameters

TSS of pulp was measured with hand Refractometer (BM, India). Total fat content of the sample was determined by the procedure of AOAC (1984). Total carotene was analyzed spectrophotometrically using β-carotene as the standard (Singh and Bradbury, 1988). Reducing sugar content was estimated by Somogyi (1952) using arseno-molybdate reagent. The soluble sugar was determined by anthrone method as described by Timpa et al. (1985). Soluble protein content was determined by the procedure of Lowry et al. (1951). Acidity was determined according to the AOAC. (2000).

3. Results and Discussion

3.1. Antioxidant contents

3.1.1. Antioxidant content of amla

The variation in antioxidants contents was observed significant in amla fruits collected from six different sites of South Gujarat showed in table 01. Amla fruit juice had the higher content of ascorbic acid found grown in Hasapur side (660.67 mg 100 g^{-1}) followed by Gandevi fruits (646.67 mg 100 g^{-1}). The present finding was in agreement with the Kumar et al., 2006. Total phenolic content in amla fruit powder varies from 8738.00 mg GAE 100 g^{-1} and The estimated catalase activity level in different places of amla fruits ranged widely from 3285.71 to 3381.76 U g^{-1} fresh weight. The fruit extract of *E. officinalis* showed the highest catalase activity in Navsari fruits (3381.76 U g^{-1} fresh weight) which is at par Karadi fruits (3374.76 U g^{-1} fresh weight), Hasapur fruits (3333.49 U g^{-1} fresh weight) and Gandevi fruits (3339.57 U g^{-1} fresh weight). The value of CAT activity is comparable with results of Vijayakumari et al. (2012). They reported Catalase activity in amla was varied from 3030.120 to 3533.333 U g^{-1} fresh weights respectively. There was no significant difference in mean values of SOD activity. However, numerically highest value of SOD activity was recorded in Gandevi location fruits (3.05433 U g^{-1} fresh weight) followed by Navsari (3.0226 U g^{-1} fresh weight). Goswami et al., 2010 amla fruit contain SOD activity about 9.247 U g^{-1} fresh weight of protein respectively. The maximum POD activity was showed in the Karadi grown fruits (10.06 U g^{-1} fresh weight) followed by Gandevi fruits (10.04 U g^{-1} fresh weight). The amla fruit extracts POD activity ranges from

Table 1: Antioxidant content of amla collected from different places of South Gujarat

Location	Ascorbic acid mg 100 g^{-1}	Total phenol mg GAE 100 g^{-1}	CAT U g^{-1} fresh weight	SOD U g^{-1} fresh weight	POD U g^{-1} fresh weight	DPPH µg ml^{-1}
Navsari	626.00	3101.02	3381.76	3.0226	10.03	73.83
Pardi	641.67	3166.72	3316.69	2.8963	9.28	74.62
Karadi	615.00	3100.96	3374.76	3.0176	10.06	73.89
Tapi	624.67	3075.09	3285.71	2.9603	9.31	73.59
Hasapur	660.67	3089.85	3333.49	2.944	10.03	73.88
Gandevi	646.67	3105.67	3339.57	3.0543	10.04	74.18
Mean	635.7 8	3106.55	3338.66	2.9825	9.79	74.00
SEm±	16.874	31.469	35.985	0.0589	0.3849	0.357
CD (*p*=0.05)	14.07163	NS	57.93014	NS	8.7928	NS

NS: Non significant

9.28 U g^{-1} fresh weight to 10.06 U g^{-1} fresh weight. Highest antioxidant activity was recorded in Gandevi location fruits (74.18 µg ml^{-1}) followed by Karadi (73.89 µg ml^{-1}) while lowest in Tapi (73.59 µg ml^{-1}) respectively.

3.1.2. Antioxidant content in jackfruit

The perusal of data presented in table 02 revealed that the antioxidant contents of jackfruit collected from different places of South Gujarat. The ascorbic acid content in jackfruit collected from different places ranged from 7.47 mg 100 g^{-1} to 8.18 mg 100 g^{-1}. The maximum content of ascorbic acid was found in the fruits of Hasapur 8.18 mg 100 g^{-1} which is at par with the fruits obtained from Songadh 8.13 mg 100 g^{-1}. Goswami et al., 2010 found similar result to above finding of ascorbic acid in jackfruit of different places of Bangladesh. The total phenol content of jackfruit ranged between (505.07 mg 100 g^{-1} to 521.31 mg 100 g^{-1}). In both places Hasapur (521.31 mg 100 g^{-1}) and Songadh (521.31 mg 100 g^{-1}) same content of total phenol was reported which is comparatively higher than other places. The result revealed similarity with the study (Jagtap et al., 2010) stated that the amount of total phenol in jackfruit pulp ranged from 440 mg 100 g^{-1} to 530.31 mg 100 g^{-1}. The higher catalase activity was detected in Hasapur region (1930.06 U g^{-1} fresh weight) which is at par with fruits obtained from Bardoli (1929.31 U g^{-1} fresh weight), Songadhn (1920.03 U g^{-1} fresh weight) and Karadi (1916.94 U g^{-1} fresh weight). The significantly higher content of catalase activity reported in Hasapur grown fruits. The SOD activity in jackfruit ranged from (2.71 to 2.43U g^{-1} fresh weight) respectively. Maximum SOD activity was observed in Karadi (2.71 U g^{-1} fresh weight) region followed by Navsari 2.66. Maximum POD activity was reported in Songadh region fruits 7.83 U g^{-1} fresh weight followed by Hasapur 7.62 U g^{-1} fresh weight. The antioxidant activity in jackfruit appreciably higher in Bardoli grown fruits 69.71 µg ml^{-1} followed by Navsari fruits 69.88 µg ml^{-1} region fruits The range of total antioxidant activity in different places was 69.71 µg ml^{-1} to 70.91 µg ml^{-1} respectively.

3.1.3. Antioxidant content of tamarind

The antioxidant potentials of tamarind fruits collected from

Table 2: Antioxidant content in jackfruit collected different places of South Gujarat

Location	Ascorbic acid mg 100 g^{-1}	Total phenol mg 100 g^{-1}	CAT U g^{-1} fresh weight	SOD U g^{-1} fresh weight	POD U g^{-1} fresh weight	DPPH µg ml^{-1}
Navsari	7.55	520.94	1910.03	2.66	7.59	69.88
Karadi	7.47	517.61	1916.94	2.71	7.18	70.51
Hasapur	8.18	521.31	1930.06	2.43	7.62	70.91
Bardoli	7.59	517.10	1929.31	2.61	7.55	69.71
Songadh	8.13	521.31	1920.03	2.52	7.83	70.22
Valsad	7.80	505.07	1880.04	2.59	7.55	70.89
Mean	7.78	517.22	1914.40	2.56	7.55	70.35
SEm±	0.3058	6.2463	18.468	0.1001	0.2105	0.505
CD (*p*=0.05)	0.1714721±	NS	18.70295	NS	NS	NS

NS: Non significant

different places of south Gujarat represented in table 03. The ascorbic acid content in tamarind fruits was appreciably higher in Dharampur fruits (3.13 mg 100 g^{-1}) followed by Navsari fruits (2.89 mg 100 g^{-1}). The lowest ascorbic acid content in tamarind pulp was observed in Chikhli fruits 2.43 mg 100 g^{-1}. Total phenol content was detected maximum in Chikhli region fruits (598.22 mg 100 g^{-1}) which is at par with Navsari fruits (588.40 mg 100 g^{-1}). Higher catalase activity was observed in Valsad region fruits (240.07 U g^{-1} fresh weight) followed by Dang (240.04 U g^{-1} fresh weight) and Chikhli (240.01 U g^{-1} fresh weight). The catalase activity of tamarind pulp ranges between (236.67 to 240.04 U g^{-1} fresh weight) respectively. Highest SOD activity was recorded in Dang tamarind fruits (0.61 U g^{-1} fresh weight) followed by Navsari and Dharampur tamarind fruits (0.60 U g^{-1} fresh weight). POD enzyme activity in tamarind pulp ranged from 2.76 U g^{-1} fresh weight to 2.97 U g^{-1} fresh

Table 3: Antioxidant content of tamarind collected from different places of South Gujarat

Location	Ascorbic acid mg 100 g^{-1}	Total phenol mg GAE 100 g^{-1}	CAT U g^{-1} fresh weight	SOD U g^{-1} fresh weight	POD U g^{-1} fresh weight	DPPH µg.ml^{-1}
Navsari	2.89	588.40	239.96	0.60	2.96	29.29
Dharampur	3.13	580.94	239.75	0.60	2.92	29.88
Valsad	2.52	580.94	240.07	0.57	2.87	29.83
Pardi	2.71	564.64	236.67	0.59	2.76	29.55
Chikhli	2.43	598.22	240.01	0.59	2.88	29.31
Dang	2.61	554.27	240.04	0.61	2.97	29.89
Mean	2.71	577.90	239.42	0.59	2.89	29.62
SEm±	0.2581	15.973	0.0136	0.013	0.0768	0.280
CD (*p*=0.05)	NS	14.155	NS	NS	NS	NS

NS: Non Significant

weight. The highest POD enzyme activity was observed from tamarind fruit pulp of Dang fruits (2.97 U g^{-1} fresh weight) followed by Navsari fruits (2.96 U g^{-1} fresh weight). Maximum total antioxidant activity recorded in Navsari fruits (29.29 µg ml^{-1}) of South Gujarat.

3.1.4. Antioxidant content of jujube

The perusal of data presented in table 04 revealed significant variations in ascorbic acid content. The jujube fruit for present study were collected from six different location of South Gujarat. The results showed the highest ascorbic acid content found in fruits collected from Vyara (76.19 mg 100 g^{-1}) which is at par with Navsari fruits (76.01 mg 100 g^{-1}) and Aat location fruits (76.07 mg 100 g^{-1}) places fruits. The significant difference in ascorbic acid content of jujube fruits might be due to difference in edible maturity stage of fruits at the time of harvesting. The maximum content of total phenol reported in Navsari fruits (16.16 mg 100 g^{-1}) which is at par with Dangm fruits (16.13 mg 100 g^{-1}). Thus the present finding was more or less similar with those reported by Krishna and Parasha, 2010. They reported amount of total phenol in jujube ranged from 5.03 mg 100 g^{-1} to 19.26 mg 100 g^{-1}. The total phenol

Table 4: Antioxidant content of jujube collected from different places of South Gujarat

Location	Ascorbic acid mg 100 g^{-1}	Total phenol mg GAE 100 g^{-1}	CAT U g^{-1} fresh weight	SOD U g^{-1} fresh weight	POD U g^{-1} fresh weight	DPPH µg ml^{-1}
Navsari	76.01	16.16	1469.84	1.94	0.618	41.94
Vyara	76.19	15.65	1484.62	1.90	0.547	41.04
Dang	75.90	16.13	1392.21	1.98	0.555	40.95
Dungri	75.76	15.99	1436.50	1.92	0.592	41.45
Bardoli	75.94	15.89	1382.17	1.89	0.610	41.33
Aat	76.07	15.43	1353.53	1.88	0.580	41.32
Mean	75.98	15.87	1419.81	1.92	0.584	41.340
SEm±	0.1479	0.285	52.064	0.0371	0.028	0.35
CD (*p*=0.05)	0.2038493	0.1537358	47.58	NS	0.024745	0.55624

NS: Non Significant

content in jujube fruit depend on the physical condition of plant. TP in jujube fruits increased from 40 to 48 days after leave fall of plant, decreased from 48 to 56 days after leave fall, again increased between 56 and 64 days after leave fall and decreased steadily after 64 days to maturity Lu et al., 2012. The higher content of TP in jujube fruits of Navsari might be due to this condition. The catalase activity in the jujube fruit collected from various locations South Gujarat differed significantly in present study. The fruit extract of jujube showed the highest catalase activity in Vyara fruits (1484.62 U g^{-1} fresh weight units g^{-1}) which is at par Navsari fruits (1469.84 U g^{-1} fresh weight), Dungari fruits (1436.50U g^{-1} fresh weight). Numerically higher value was found in place Dang fruits (1.98U g^{-1} fresh weight) followed by Navsari fruits (1.94U g^{-1} fresh weight) and Dungri fruits (1.92U g^{-1} fresh weight). The range of SOD activity in jujube fruits was 1.88 to 1.98 U g^{-1} fresh weight respectively. Highest POD activity was observed in the jujube fruits of Navsari (0.618 U g^{-1} fresh weight) which was at par with Bardoli grown fruits (6.10 U g^{-1} fresh weight). The antioxidant activity (DPPH scavenging activity IC50 µg ml^{-1}) in different location of South Gujarat. Significantly higher content was found in Dang fruits (40.95 µg ml^{-1}) Navsari fruits (41.94 µg ml^{-1}), and fruits of Bardoli (41.33 µg ml^{-1}) respectively. The value of antioxidant activity is comparable with results of Wei et al., 2005. They obtained DPPH scavenging IC50 µg ml^{-1} in jujube fruit ranged from 33.65 to 98.6 µg ml^{-1} respectively.

3.2. Biochemical content

3.2.1. Biochemical content of Amla

The results showed the highest TSS was found in Navsari (9.04 °Brix) region (Table 5). Nayak et al. (2012) have reported higher total soluble solids (TSS) content of amla fruits (9.3 to 11.00 °Brix) than present findings which might be due to variation in agro climatic conditions. Maximum TF content 0.13 g 100 g^{-1} was obtained in fruits of Navsari followed by Hasapur fruits (0.12 g 100 g^{-1}) though the difference of TF content in different place was non-significant. The fat content in amla was about 0.1 to 0.6 g 10 g^{-1} reported by Gopalan et al. (1991). The data regarding to the carotene content in fruits of amla did not differ significantly. Maximum carotene content recorded same in Hasapur 57 µm 100 g^{-1} followed by Navsari 56 µm 100 g^{-1}. The carotene content in above finding is lower than the USDA National Nutrient data base (2013). Maximum RS content recorded in Gandevi 3.86 g 100 g^{-1} which is at par with fruits of Navsari 3.59 g 100 g^{-1}. A non-significant difference in total soluble sugar (SS) was observed among different locations of South Gujarat in amla fruits. Nayak et al. (2012) reported soluble sugar content of amla varied from 6.8 to 9.1 g 100 g^{-1} which is slightly similar with our results respectively. TSP of amla fruit did not differ significantly in different location and ranged from 0.80 g 100 g^{-1} to 0.86 g 100 g^{-1}. The fruit of Hasapur was having the highest TSP content 0.86 g 100 g^{-1} followed by Pardi fruits 0.85 g 100 g^{-1}. Gopalan et al. (1991) reported protein content in amla was about 0.5 to 1.0 g 100 g^{-1} which are in agree with above findings. Significant variation in acidity in different places of South Gujarat was noted which ranged from 2.75 to 3.86 g 100 g^{-1} (Table 05). Amla fruits of Pardi had the highest values of acidity 3.86 g 100 g^{-1} which is at par with tapi 3.42 g 100 g^{-1}.

3.2.2. Biochemical content of Jackfruit

The results showed the highest TSS content in Karadi fruits 17.12 °Brix which was at par with Songadh 16.99 g^{-1} 100 g^{-1} while the lowest in Bardoli fruits 16.36 g/100 °Brix which is at par with Hasapur fruits 16.45 °Brix. This result is similar to that reported by Haque (1991) ranged between 14°Brix to 21.5 °Brix respectively. There was no significant differences in total fat content were observed among different locations of South Gujarat in jackfruit pulp (Table 6). Higher fat content was observed in Karadi fruits (0.16 g 100 g^{-1}). Purseglove (1968) and Bhatia et al. (1955) reported similar fat content as above finding in jackfruit ranged from 0.15 to 0.22 g 100 g^{-1} respectively. The range of total carotene content in jackfruit pulp varied from 115 µg 100 g^{-1} to 126 µg 100 g^{-1}

Table 5: Biochemical parameters of amla collected different places of South Gujarat

Location	TSS °Brix	Total fat g 100 g^{-1}	Carotene µg 100 g^{-1}	Reducing sugar g 100 g^{-1}	Total soluble sugar g 100 g^{-1}	Soluble protein g 100 g^{-1}	Acidity g 100 g^{-1}
Navsari	8.65	0.13	56	3.59	6.54	0.83	2.75
Pardi	8.99	0.10	54	3.02	6.88	0.85	3.86
Karadi	8.60	0.11	56	3.42	6.61	0.80	3.20
Tapi	8.67	0.11	55	2.89	7.03	0.83	3.42
Hasapur	9.04	0.12	57	2.99	7.08	0.84	3.05
Gandevi	9.00	0.11	55	3.86	6.60	0.86	2.86
Mean	8.83	0.12	55	3.30	6.79	0.84	3.19
SEm±	0.204	0.010	1.048	0.388	0.236	0.020	0.405
CD (*p*=0.05)	0.165	NS	NS	0.598	NS	NS	0.579

NS: Non significant

in various places; however the effect of different places was not significantly differed (Table 6). Numerically higher value was found under place Navsari 126 µg 100 g^{-1}. Hossain and Haque (1979) found values of carotene in jackfruit pulp ranging from 250 to 1745 µg 100 g^{-1} are near about reported in above findings. The different components of carbohydrate content like reducing sugar and total soluble sugar were not affected significantly due to variation in places. However, numerically higher value of reducing sugar and total soluble sugar were recorded in the Bardoli fruits 11.02 g 100 g^{-1} and 14.36 g 100 g^{-1}. The value of reducing sugar was about 10 g 100 g^{-1} reported by Hossain and Haque (1979). The total soluble sugar varied from 13.80 to 17.89 g 100 g^{-1} comparable with results of Goswami et al. (2011). Higher content of soluble protein was found in Songadh 1.16 g 100 g^{-1}. Highest acidity was found in Bardoli (0.48 g 100 g^{-1}) region whereas lowest acidity found in Valsad (0.43 g 100 g^{-1}) region respectively.

Table 6: Biochemical parameters of jackfruit collected different places of South Gujarat

Location	TSS °Brix	Total fat g 100 g^{-1}	Carotene µg 100 g^{-1}	Reducing sugar g 100 g^{-1}	Total soluble sugar g 100 g^{-1}	Soluble protein g 100 g^{-1}	Acidity g 100 g^{-1}
Navsari	16.87	0.11	126	10.79	13.90	1.15	0.46
Karadi	17.12	0.16	115	10.79	13.89	1.13	0.45
Hasapur	16.45	0.10	121	10.96	14.00	1.14	0.45
Bardoli	16.36	0.11	118	11.02	14.36	1.15	0.48
Songadh	16.99	0.10	120	10.85	14.01	1.16	0.47
Valsad	16.60	0.09	118	10.90	13.93	1.13	0.43
Mean	16.73	0.18	119	10.88	14.01	1.14	0.46
SEm±	0.307	0.024	3.723	0.093	0.176	0.012	0.017
CD (*p*=0.05)	0.22201	NS	NS	NS	NS	NS	NS

NS: Non significant

The different components of carbohydrate content like reducing sugar and total soluble sugar were not affected significantly due to variation in places. However, numerically higher value of reducing sugar and total soluble sugar were recorded in the Bardoli fruits 11.02 g 100 g^{-1} and 14.36 g 100 g^{-1}. The value of reducing sugar was about 10 g 100 g^{-1} reported by Hossain and Haque (1979). The total soluble sugar varied from 13.80 to 17.89 g 100 g^{-1} comparable with results of Goswami et al. (2011). Higher content of soluble protein was found in Songadh 1.16 g 100 g^{-1}. Highest acidity was found in Bardoli (0.48 g 100 g^{-1}) region whereas lowest acidity found in Valsad (0.43 g 100 g^{-1}) region respectively.

3.2.3. Biochemical content of tamarind

A very little difference in TSS content of that ranged from 39.75 °Brix to 40.07 °Brix was observed among tamarind fruits. The fruits of Pardi were having the highest TSS content followed by Dang 40.04 °Brix Valsad and Chikhli 40.01 °Brix grown fruits. The earlier work done by Anon (1982) reveled that TSS content tamarind fruit ranges from 28 g 100 g^{-1} to 62 g 100 g^{-1}. Total fat content in tamarind did not differ significantly in respect of different places of South Gujarat (Table 7). Maximum TF content 0.61 g 100 g^{-1} was obtained in fruits of Dharampur which was significantly higher compared to other cultivars. The result of above finding similar with reported by Coronel (1991); Feungchan et al. (1996). Maximum carotene content recorded same in Dharampur and Dang 22 µg 100 g^{-1}. The present finding was more or less similar with those reported by Duke (1981); Narasimham (1990). They reported amount of carotene content in jackfruits ranged from 20 µg 100 g^{-1} to 25 µg 100 g^{-1} respectively. The maximum value of reducing sugar and total soluble sugar was reported in Pardi side fruits

Table 7: Biochemical parameters of tamarind collected different places of South Gujarat

Location	TSS °Brix	Total fat g 100 g^{-1}	Carotene µg 100 g^{-1}	Reducing sugar g 100 g^{-1}	Total soluble sugar g 100 g^{-1}	Soluble protein g 100 g^{-1}	Acidity g 100 g^{-1}
Navsari	39.96	0.60	21	16.95	19.30	3.02	12.08
Dharampur	39.75	0.60	22	17.57	19.70	2.95	12.17
Valsad	40.01	0.61	21	17.27	19.29	2.93	12.09
Pardi	40.07	0.59	21	18.09	19.57	2.96	12.00
Chikhli	40.01	0.59	21	17.74	19.79	2.99	12.10
Dang	40.04	0.60	22	18.01	19.49	2.95	11.99
Mean	39.97	0.60	21	17.61	19.52	2.97	12.07
SEm±	0.115	0.007	0.516	0.438	0.204	0.032	0.067
CD (*p*=0.05)	NS	NS	NS	NS	NS	NS	NS

NS: Non significant

(18.09 and 19.57 g 100 g^{-1}). Results of above findings were comparable to the reported results of Meillon (1974) and Parvez et al. (2003) in which reducing sugar ranged from 25.00 g 100 g^{-1} to 45.00 g 100 g^{-1} RS and total soluble sugar (SS) percentage also similar with findings of Marangoni et al. (1988) which was approximately 20 g 100 g^{-1}. The maximum content of TSP reported in Navsari fruits (3.02 g 100 g^{-1}) followed by Chikhli fruits (2.99 g 100 g^{-1}). The observed data was supported by the work of Purseglove (1987) and Wenkam and Miller (1965) and TSP ranged from 3.10 g 100 g^{-1} to 3.40 g 100 g^{-1}. Significant variation in acidity in tamarind of different places of South Gujarat was noted, which ranged from 11.99 to 12.17 g 100 g^{-1} (Table 07). Tamarind fruits of Dharampur (12.17g 100 g^{-1}) had the highest values of TA and the fruits of Dang had the lowest values of TA (11.99 g 100 g^{-1}). Similar range of TA found by Meillon (1974) was from8.94 to 14.98 in tamarind.

3.2.4. Biochemical content of jujube

The data regarding to the TSS content in fruits of Indian jujube different location did not differ significantly (Table 8). Maximum TSS content recorded in Vyara 17.57 °Brix. According to Bhatia and Gupta (1985) total soluble solids ratio of Indian jujube was 16.70 °Brix to 17.0 °Brix which is more or less similar with above finding. Total soluble solids in various Indian jujube cultivars varied between 15 to 21 °Brix (Chadha et al., 1972), whereas they observed TSS in Indian jujube cultivar Umran was 19 °Brix. Non significant differences in total fat content were observed among different locations of South Gujarat in Indian jujube fruit (Table 8). The higher total fat content recorded in Vyara 0.89 g 100 g^{-1}. Li et al. (2007) reported that fat content in jujube varied from 0.37 to1.024 g 100 g^{-1}, and the result of varied between the range 0.86 to 0.89 g 100 g^{-1}. Maximum carotene content was reported in Bardoli region fruits 534 µg 100 g^{-1} followed by Navsari fruits 521 µg 100 g^{-1}. The different parts of carbohydrate content like reducing sugar and total soluble sugar were not affected significantly in the Indian jujube fruits of different places. However, numerically higher value of reducing sugar and total soluble sugar were recorded with the Dang 5.69 g 100 g^{-1} and 7.94 g 100 g^{-1} respectively, whereas lower content of both the sugar were observed in Bardoli 4.40 g 100 g^{-1} in case of reducing sugar and 7.40 g 100 g^{-1} in case of total soluble sugar in Navsari respectively (Table 8). The values of reducing sugar and total soluble sugar are comparable with results of Pareek and Dhaka (2008). Teotia et al. (1974) recorded total sugars and reducing sugars content of various Indian jujube cultivars and reported that the range for total sugars was 3.452 to 9.673% and that for reducing sugars was 3.274 to 9.77% respectively. Higher content of TSP was found in Dungri fruits (1.15 g 100 g^{-1}). Morton, (1987) reported the protein contain of Indian jujube 0.8 g 100 g^{-1} which are very close to our finding.

Table 8: Biochemical parameters of Indian jujube collected different places of South Gujarat

Location	TSS °Brix	Total fat g 100 g^{-1}	Carotene µg 100 g^{-1}	Reducing sugar g 100 g^{-1}	Total soluble sugar g 100 g^{-1}	Soluble protein g 100 g^{-1}	Acidity g 100 g^{-1}
Navsari	16.95	0.88	521	4.75	7.40	0.90	0.490
Vyara	17.57	0.89	443	4.74	7.41	1.07	0.465
Dang	17.27	0.85	428	5.69	7.94	0.99	0.409
Dungri	18.14	0.88	483	4.73	7.03	1.15	0.472
Bardoli	17.26	0.87	534	4.40	7.42	0.93	0.486
Aat	17.08	0.87	511	4.53	7.60	1.11	0.420
Mean	17.38	0.873	487	4.81	7.46	1.03	0.457
SEm±	0.427	0.013	43.297	0.455	0.297	0.100	0.034
CD (p=0.05)	NS	NS	NS	NS	NS	0.131	0.018

NS: Non significant

The maximum content of total soluble proteine was obtained in Dugri grown fruits of Indian jujube may be due to cultivars difference. The Yazao fruit cultivar difference had higher protein content compare to Jinsixiaozao, JianzaoJunzao and Sanbianhong cultivars of Indian jujube Li et al. (2007). There was significant difference in acidity content of Indian jujube fruits among different locations. Highest acidity was found in Navsari (0.490 g 100 g^{-1}) region.

4. Conclusion

Minor fruits of this region is very much rich in antioxidants and nutritional parameters which can fulfill the nutritional need of the poor villagers of this region and not only that if it is cultivated in an economically with proper agronomic package and practice, for table purpose fruit it can fetch a fair amount of market price.

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