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Comparative analysis of nutritional parameters of organically and conventionally cultivated selected fruits from South Gujarat

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Abstract
Fifty samples of mango fruit (*Mangifera indica*) and forty-eight samples each of banana (*Musa acuminata*) and papaya (*Carica papaya*) fruits were collected from organically and conventionally cultivated land. Mango fruits were analyzed for total sugar, reducing sugar, protein, vitamin C, β-carotene, B2 (Riboflavin), B3 (Niacin), B9 (folic acid), and total antioxidant power (capacity). Whereas, banana and papaya fruits were analyzed for total sugar, reducing sugar, protein, vitamin C, B-carotene, B2 (Riboflavin), B3 (Niacin), B9 (folic acid), and micronutrients like Fe, Mn, Zn, and Cu. The results indicated better quality parameters of for mango, banana, and papaya when grown organically than conventionally. However, organic mango contains significantly higher protein, vitamin C, B2, B3, and B9 than conventionally grown mango. In the case of bananas, the content of protein, total sugar, TSS, vitamin C, B3, and B2 were found significantly higher in organically grown than the conventional. Similarly in papaya, protein, reducing sugar, Fe, and B3 contents were found significantly higher in organically grown papaya than conventional ones.

Keywords: Organic, β -carotene, Riboflavin, Niacin, folic acid

Introduction

Fruits and vegetables are the integral part of the healthy diet. They are the major sources of water, carbohydrates, fats, proteins, fiber, minerals, organic acids, vitamins, and antioxidants. Almost fruits and vegetables are available nearly time-round in a wide variety and can be consumed as fresh and also as cooked, hot or cold, canned, pickled, firmed or dried. Fruits and vegetables are fairly low in calories and fat. Thus, these are associated with reduced cardiovascular ailments and minimize the chances of cardiac arrest. (Bazzano *et al*. 2002; Gillman *et al*. 1995; Joshipura *et al*. 2001) [2, 7, 11]. India is one of the dominating countries in fruit products in the world. Gujarat is one of the frontal runner states in fruit and vegetable products. South Gujarat, considering the immense growth eventuality of this sector, this region has been declared Special Export Zone for fruit and vegetables by the State Government. The Gujarat government has encouraged the organic cultivation of various fruits and vegetables. In the contemporary world, the multi-billion dollar organic food industry is fuelled by consumer perception that organic food is healthier. Organic farming involves horticultural practices that avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. The organically cultivated food crops have a vast export potential which is growing at around 10-15 percent per year. (Crinnion 2010) [5]. Various debates on organic food effort to be made scientifically by interjecting reproducible facts into the debate: Is the quality of organic food higher than that of conventional foods? (Wojciech *et al*. 2009) [30].

The present study aimed to analyze nutritional composition of organic and conventionally grown mangoes, bananas, and papaya for their and thereby establish the impact of differential nutrient management agricultural practices on the quality of mango, banana, and papaya fruit.

Mango is the most important fruit crop covering about 36 percent and accounting for 20.3 percent of total fruit production in the country, which is almost in the world with India's share of about 39 percent. Major mango-growing states are Uttar Pradesh, Bihar, Andhra Pradesh, Orissa, West Bengal, Maharashtra, Gujarat, Karnataka, Kerala and Tamil Nadu.

The main types of mango grown in the country are Alphanso, Dashehari, Langra, Kesar, Fajli, Chausa, Totapuri, and Neelum.

Banana comes next in rank about 13.0 percent of the total area and account for about 39.8 percent of the total product of fruits in the country. Bananas are rich in vitamin B6 and also good sources of fiber, vitamin C, magnesium, and potassium. Lack of B6 in a diet can bring weakness, awkwardness, and insomnia (Mohpatara *et al.* 2010) [16]. India gripped the first position in the world in banana. Tamil Nadu is the leading state with a share of 27.7 percent and has the loftiest productivity of 65.8 metric tonnes against India's average of 35.9 metric tonnes per hectare. The other major banana-growing states are Maharashtra, Gujarat, Andhra Pradesh and Karnataka.

Papaya is the other important fruit crop entrapping only one percent of the area but its product accounts for 5.6 percent of total fruits produced in the country, which is the loftiest in the world with India's share of about 39.3 percent (Indian Horticulture Database 2011). Papayas are a good source of vitamin C and A. Papaya ranks first among 13-17 fresh fruits for vitamin C content per 100 g edible tissue (Gebhardt *et al*. 2002; Vinci *et al*. 1995) [6, 28].

Materials and Methods

Sampling

Mango, banana, and papaya fruits were collected from the organic and inorganic farm of Navsari Agricultural University and a well-managed farm in south Gujarat. Samples were physically cleaned by rinsing with deionized water to remove dirt and other extraneous filth. Collected fruit samples were subjected to natural ripening and analyzed for various biochemical and chemical quality parameters.

Chemicals and Reagents

Standards of β-carotene Type I (95% purity, UV), riboflavin, nicotinic acid, folic acid, and ascorbic acid were obtained from Hi-media Laboratories Pvt. Ltd. Iron and Zinc Standards were obtained from RANKEM Fine Chemicals Ltd (RFCL), India. All of the solvents and chemicals used in this study were of analytical grade.

Sample Preparation

Thoroughly cleaned samples were chopped and homogenized on the commercial food processor. Homogenized fruit samples (pulp) were preserved in a deep freezer (-20 ^{0}C) till they were analyzed. Various standard methods as mentioned below were followed for analyzing the nutrient parameters.

Total sugar (TS)

The sample extract was prepared by hydrolyzing the test sample in 2.5N HCl for three hours in a boiling water bath, followed by neutralizing it with sodium carbonate. It was then centrifuged and the supernatant was collected for analysis. The TS was estimated by using Anthrone’s reagent (Rangana *et al*. 1979) [21]. 1 mL of alcoholic extract was taken in a test tube and chilled followed by pouring of 4 mL of anthrone’s reagent along the walls of the test tube. The test tubes were kept in ice water. The tubes were brought to ambient temperature and boiled in a water bath for 10 min. After proper cooling, the absorbance was measured at 625 nm.

Reducing Sugar (RS)

The extract was prepared by taking 0.5 g of fresh pulp and extracting the same with 80% ethanol by centrifuging three times. The supernatant was collected and a measured quantity of distilled water was added to it, and heated until all ethanol evaporated. Then volume of the sample was made up to 150 mL by adding distilled water. RS was estimated using a Dinitrosalicylic acid (DNS) reagent (Miller 1972) [15]. 3 mL of DNS reagent was added to 3 mL of sample in a lightly capped test tube. The mixture was heated at 90 ºC for 5-15 minutes to attain a red-brown color. Then 1 mL of Rochelle’s salt solution was added to stabilize the colour. Absorbance was recorded at 510 nm after cooling to room temperature in a cold water bath.

Brix: Brix value was measured using a refractometer (AST Model RX-5000CX, Atago Co. Ltd.).

Protein

Protein was estimated following the method of Lowry *et al.* (1951) [13]. 0.5 g of sample was taken and extracted in 0.2M phosphate buffer (pH 7.0), centrifuge at 10000 rpm for 10min. Supernatants were used as a sample. Different dilutions of BSA solutions were prepared from stock BSA solution (1 mg/ ml) using distilled water. The final volume in each test tubes were 5 ml. The BSA range was 0.05 to 1 mg/ ml. 0.2 ml protein solution were taken in tubes, 2 ml of alkaline copper sulfate reagent were added to each. The mixture was incubated at room temperature for 10 min. Then add 0.2 ml of reagent Folin Ciocalteau solution to each tube and incubated for 30 min. The absorbance was measure at 660 nm and standard curve for known concentration was prepared. The value of unknown sample was derived from the standard curve.

Ascorbic acid

Ascorbic acid was estimated through the iodine titration method Harris and Ray (1935) [8]. Five mL working standard solution was taken in 100 mL conical flask. It was added with 10 ml of 4% oxalic acid and was titrated against the dye (Iodine solution). Development of pink colour was considered as end point. Here the amount of dye consumed is considered as equivalent to the amount of ascorbic acid.

Extract 0.5g sample in 4% oxalic acid and makeup to a known volume (100ml) and centrifuge. Pipette out 5mL of this supernatant, add 10ml of 4% oxalic acid, and titrate against the dye.

Mineral

A representative sample (0.5g) of each fruit pulp was digested using diced (nitric acid and perchloric acid) in a microwave digestion unit. The digested samples were used for elemental analysis. Iron (Fe), Manganese (Mn), Copper (Cu), and Zinc (Zn) were determined using inductively coupled plasma mass spectrometry (ICP-MS) (Jajda *et al.* 2013) [10].

Beta carotene

β-carotene was estimated according to the method developed by Biswas *et al*. (2011) [3]. 1 g of fruit sample was extracted with chilled acetone and made up a volume of 10 ml with it. Sonicated the sample in ultra sonicator for 1 hour. The tubes were centrifuged at 5000 rpm for 10 min. The supernatant was collected was re-extracted with 5 ml of acetone followed by centrifugation once again as above.

Both of the supernatants were pooled together and then passed through the Whatman filter paper. The absorbance of the extract was determined at 449 nm in a UV-vis spectrophotometer.

Vitamins

The high-performance liquid chromatographic system was used for vitamin estimation. HPLC column discovery C18, 25cm x 4.6mm, 5cm (Supelco, Sigma-Aldrich) was used for the separation of vitamins. A gradient of methanol and buffer (30:70, in eight minutes) of 50 mM (0.05M) potassium dihydrogen phosphate having pH 4.2 + 0.1 was used as the mobile phase. The flow rate was maintained at 1 ml min^{-1}. The wavelength of detection was 254 nm. An injection volume of 20 mL was chromatographed, and the whole chromatography was performed at ambient temperature. The standard of Riboflavin (B2), Nicotinamide (B3), and Folic acid (B9) (each) were accurately weighed mg/ml. Riboflavin was dissolved in water and Nicotinamide was dissolved in methanol. Folic acid was prepared in water + 50 µL 1 M NaOH. Sample extraction was carried out by taking 0.5 g of the sample and extracted in phosphate buffer (pH-4.0). Keep all tubes in a boiling water bath for 1 hour. Sonicate the sample in ultra sonicator for 1 hour. Centrifuge the tubes at 7000 rpm for 10 min. Collect the supernatant in another tube and filter the sample through a microfilter (diameter 0.2 mm) collect it in HPLC vials and analyze it on HPLC (Russell 2000) [25].

Total Antioxidant power/ FRAP analysis

Ferric reducing antioxidant power (FRAP) analysis was carried out according to Szollosi and Szollosi (2002) [27]. Leave samples (1.0 g each) of all five varieties were powdered by using LN2. It was homogenized in 9 ml cool 0.1 M phosphate buffer (pH 7.6, containing 0.1 mM EDTA) in a pre-chilled mortar and pestle. This mixture was filtered through a filter paper and centrifuged at 15000 rpm for 10 min. The supernatant was used for the measurements. 1.5 ml of FRAP reagent and 5 ml of plant extract were mixed and absorbance was taken at 593nm. FRAP reagent (25 ml acetate buffer 300 m*M* pH 3.6, 2.5 ml 10 mM 2,4,6-tripyridyl-s-triazine (TPTZ) in 40 mM HCl and 2.5 ml 20 mM FeCl3 6 H2O in distilled water) was used as a blank. Aqueous solution of known Fe (II) concentration was used for calibration (100-1000 µM).

Statistical analysis

Variations in the treatments were determined by applying analysis of variance (ANOVA) techniques. The standard error (S. Em.), CD @ 5%, and C.V. % were also calculated.

Results

Nutritional content of mango

Among analyzed various nutrients in organic mango, the result revealed that it contains 272 mg/g total sugar, 57 mg/g reducing sugar, 12.9 mg/g protein, 36.4 mg/100g vitamin C, 3.0 mg/100g β-carotene, 9.5 µg/g B2 (Riboflavin), 1327 µg/g B3 (Niacin), 74 µg/g B9 (folic acid) and 6.9 mM/g total antioxidant power. Whereas inorganic mango contains 265 mg/g total sugar, 56 mg/g reducing sugar, 10.5 mg/g protein, 33.4 mg/100g vitamin C, 2.7 mg/100g β-carotene, 8.2 µg/g B2 (Riboflavin), 1218 µg/g B3 (Niacin), 67 µg/g B9 (folic acid) and 6.0 mM/g total antioxidant power. Upon statistical analysis among analyzed parameters, the organic mango contains significantly higher protein, vitamin C, B2, B3, and B9 than conventionally grown mango (Table 1).

Table 1: Nutritional content of mango

Parameter	Inorganic	Organic	S.Em +	C.D @ 5%	C.V.%
Protein(mg/gm)	10.5	12.9	0.1	0.3	3.5
Total sugar (mg/gm)	265	272	5.0	NS	6.8
RS (mg/gm)	56	57	1.7	NS	12.1
B-carotene (mg/100gm)	2.7	3.0	0.1	NS	14.7
Total antioxidant Power (mM/gm)	6.0	6.9	0.09	0.3	5.7
Vit. C (mg/100gm)	33.4	36.4	0.4	1.3	5.0
Niacin (ug/gm)	1218	1327	15	44	4.8
Folic acid (ug/gm)	67	74	1.1	3	6.4
Riboflavin (ug/gm)	8.2	9.5	0.09	0.3	3.9

Table 2: Nutritional content of banana

Parameter	Inorganic	Organic	S.Em +	C.D @ 5%	C.V.%
Protein (mg/gm)	12.7	14.5	0.32	1.0	5.9
Total sugar (mg/gm)	202.5	225.3	5.9	17.8	6.9
RS (mg/gm)	127.9	126.5	4.1	NS	8.3
TSS (%)	17.9	18.8	0.17	0.51	2.4
B-carotene (mg/100gm)	89.0	84.9	1.5	NS	4.6
Fe (ppm)	20.1	22.3	0.9	NS	11.5
Mn (ppm)	7.8	7.3	0.4	NS	13.4
Zn (ppm)	11.5	10.6	0.6	NS	13.4
Cu (ppm)	0.8	1.2	0.08	0.3	18.2
Vit. C (mg/100gm)	4.0	5.9	0.2	0.5	7.8
Niacin (ug/gm)	309.0	378.7	5.7	17.0	4.0
Folic acid (ug/gm)	21.9	20.8	0.4	NS	5.4
Riboflavin (ug/gm)	1.2	1.6	0.06	0.2	9.9

Nutritional content of papaya

In case of banana, the organic banana contains 18.8% TSS, 225.3 mg/g total sugar, 126.5 mg/g reducing sugar, 14.5 mg/g protein, 5.9 mg/100g vitamin C, 84.9 ug/100g β-carotene, 1.6 ug/g B2 (Riboflavin), 378.7 ug/g B3 (Niacin), 20.8 ug/g B9 (folic acid), 22.3 ppm Fe, 7.3 ppm Mn, 10.6 ppm Zn and 1.2 ppm Cu. Whereas inorganic banana, the contents found to be 17.9% TSS, 2.5 mg/g total sugar, 127.9 mg/g reducing sugar, 12.7 mg/g protein, 4.0 mg/100g vitamin C, 89.0 µg/100g β- carotene, 1.2 µg/g B2 (Riboflavin), 309.0 µg/g B3 (Niacin), 21.9 µg/g B9 (folic acid), 20.1 ppm Fe, 7.8 ppm Mn, 11.5 ppm Zn and 0.8 ppm Cu. Protein, total sugar, TSS, vitamin C, B3, B2, and Cu were found significantly higher in organic than conventionally grown bananas (Table 2).

Nutritional content of papaya

The nutritional quality of organic papaya was analyzed which revealed that it contains 9.3% TSS, 191.0 mg/g total sugar, 92.7 mg/g reducing sugar, 30.4 mg/g protein, 58.9 mg/100g vitamin C, 0.30 µg/100g β-carotene, 455.6 µg/g B3 (Niacin), 20.2 µg/g B9 (folic acid), 50.4 ppm Fe, 19.1 ppm Mn, 10.0 ppm Zn and 0.6 ppm Cu. Whereas inorganic papaya, the contents found to be 8.9% SS, 2.8 mg/g total sugar, 65.7 mg/g reducing sugar, 26.6 mg/g protein, 55.4 mg/100g vitamin C, 0.25 mg/100g β-carotene, 337.2 µg/g B3 (Niacin), 19.8 µg/g B9 (folic acid), 47.0 ppm Fe, 21.1 ppm Mn, 9.2 ppm Zn and 0.5 ppm Cu. Among different quality parameters, protein, reducing sugar, iron, and B3 contents were found significantly higher in organically grown papaya than in conventional ones (Table 3).

Table 3: Nutritional content of papaya

Parameter	Inorganic	Organic	S.Em +	C.D @ 5%	C.V.%
Protein (mg/gm)	27.6	30.4	0.6	1.7	4.8
Total sugar (mg/gm)	192.8	191.0	1.6	NS	2.2
RS (mg/gm)	65.7	92.7	0.8	2.1	2.0
TSS (%)	8.9	9.3	0.2	NS	4.3
B-carotene (mg/100gm)	0.25	0.30	0.02	NS	13.0
Fe (ppm)	47.0	50.4	0.8	2.3	4.0
Mn (ppm)	21.1	19.1	0.7	NS	9.5
Zn (ppm)	9.2	10.0	0.3	NS	8.8
Cu (ppm)	0.5	0.6	0.03	NS	14.4
Vit. C (mg/100gm)	55.4	58.9	1.3	NS	5.7
Niacin (ug/gm)	337.2	455.6	8.8	26.4	5.1
Folic acid (ug/gm)	19.8	20.2	0.4	NS	4.4

Discussion

As a general rule, in studies that have paired common production variables and methodologies, organic crops tend to have more vitamin C and sugars than conventionally grown produce similar to our result, which corroborates findings of nutritional reviews (Raigon *et al*. 2010; Soltoft *et al*. 2010; Juroszek *et al*. 2009; Pereira Lima *et al*. 2008; Marzouk *et al*. 2011) [20, 26, 12, 19, 14]. Contradiction to our findings organic crops tend to have less protein (Riahi *et al*. 2009; Roussos *et al*. 2009) [23, 24]. Patterns of differences between organic and conventional foods concerning heavy metals or specific minerals are not apparent. In the present study banana and papaya were analyzed for Fe, Mn, Zn, and Cu which shows only copper was significantly increased in the banana as Fe was significantly increased in papaya. In corroboration of our study, individual studies show differing levels of some minerals, but differences are dependent upon the particular fruit, leafy vegetable, or root crop. For example, when organically versus conventionally grown produce samples were compared, carrots had higher B, Cu, Mn, and N (Heardter *et al*. 2005) [9] potatoes had higher Mg (Warman *et al*. 1998) [29], cabbage had higher Mn, N, and Zn, (Heardter *et al*. 2005) [9] and sweet corn had higher Ca, Cu, Mg, and P (Warman *et al*. 1998) [29] whereas tomatoes had higher in Ca, N, Na and P (Colla *et al*. 2002) [4]. Organic carrots contained less β-carotene and more total sugars, but the differences were statistically insignificant (Rembialkowska *et al*. 2003) [22] which is in agreement with the data obtained in our study in all three fruits. Evidence for B-complex vitamins being higher in organic versus conventional foods was inconclusive (Amodio *et al*. 2003) [1] similar to our finding which shows inconsistent trends in three B-complex vitamins B2, B3, and B9 content in all three fruits. All three vitamin contents were found significantly higher in organic mango than in organic banana B2 and B3 and in organic papaya, only B3 was found significantly higher. The levels of antioxidant compounds tend to be higher in organic foods compared with conventional foods (Amodio *et al*. 2003) [1], in corroboration with our result we found higher antioxidants in organic mango compared to conventional ones. Recent publications support that the reason behind the improved quality of organic fruits is due to the stress physiology of plants (Oliveira *et al*. 2013) [18]. In a review of organic versus conventional production, the author stated that "the evidence seems to favor enhancement by organic production systems" (Zhao *et al*. 2006) [31]. Further, they cautioned that "there has been a little systematic study of the factors that contribute to increased nutritional content in organic crops and it remains to be seen whether consistent differences will be found, and the extent to which biotic and abiotic stresses, and other factors such as soil biology, contribute to those differences".

Conclusion:

Results of the present study show that organically grown fruits contain higher nutrients compared with conventional practiced fruits. The result of the present study should be useful for general consumers, physicians, and dieticians. Moreover, the information from this study will be useful for promoting or increasing organic fruit consumption.

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