



Fruit quality, antioxidant enzymes activity and yield of six cultivars of grapefruit (*Citrus paradisi*) grown under subtropical conditions

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ABSTRACT

Experiment was conducted on six cultivars of grapefruit (*Citrus paradisi* Macf.) namely, Imperial, Duncan, Foster, Marsh SL, Star Ruby and Redblush during 2009-2011. Plants of these cultivars were spaced at 4 m × 4 m apart. Fruit yield was found to be the highest (31.48 kg/tree) in Imperial followed by Foster (23.43 kg/tree). However, heaviest fruit (414.01 g) was recorded in Foster and the lowest fruit weight (282.89 g) was in Redblush. Duncan and Marsh SL had the highest juice recovery (50.00%) which was not differed significantly with Redblush (46.91%). The lowest juice recovery was found in Foster and Imperial. Imperial had thickest peel (6.99 mm) and peelthickness was least in Foster (5.30 mm). Whereas, seeds/fruit was recorded the highest in Foster and Imperial (> 44 seeds /fruit). Other cultivars like, Marsh SL, Star Ruby and Redblush had less than 5 seeds/fruit and seems to be seedless. Mean TSS was recorded maximum in Duncan (9.56%) which was at par with Marsh SL (9.53%) and Redblush (9.50%). The minnum TSS was found in Star Ruby (8.82%) which did not differ significantly with Foster. Significantly lower acidity was recorded in Marsh SL (0.81%), Imperial (0.85%) and Foster (0.94%). While maximum acidity was found in Duncan (1.09%). The higher ascorbic acid content (56.53 mg/100 ml juice) was estimated in Marsh SL followed by Foster (49.61 mg/100 ml juice). Whereas, maximum AOX activity (5.56 μ mol Trolox eq/g) was recorded in Imperial followed by Marsh SL (5.08 μ mol Trolox eq/g) and Redblush (4.53 μ mol Trolox eq/g). The most promising grapefruit cultivars, based on yield and quality, were Marsh SL, Redblush and Imperial.

Key words: Antioxidant activity, Ascorbic acid, Grapefruit, Sub-tropical, Yield

The grapefruit (*Citrus paradisi* Macf.) was first described in 1750 by Griffith Hughes who called it the “forbidden fruit” of Barbados. By 1910, grapefruit had become an important commercial crop in the Rio Grande Valley and, to a lesser extent, in Arizona and desert valleys of California. Cultivation had reached commercial proportions in Jamaica and Trinidad and spread to Brazil, South America and Israel. Grapefruit was moving forward by leaps and bounds. Other countries which had entered the grapefruit industry were Mexico, Argentina, Cyprus, Morocco and some areas of South America which raise grapefruit for local markets. In India, its introduction is comparatively recent, and its cultivation is confined mostly to Punjab, the western parts of Uttar Pradesh and to places around Pune in Maharashtra. Grapefruits are the only citrus taxon which have known origin (Scora *et al.* 1982, Kumamoto *et al.* 1987, Yamamoto *et al.* 1993), and are native to the Barbados Islands in the Caribbean. There are three most economically important variety groups of grapefruits: 1. the seeded fruits with pale-

yellow pulp (Duncan, MacCarty, Triumph, Imperial and Walters), 2. pale-yellow pulp, but seedless (Marsh Seedless), and 3. The pigmentedpulp (Thompson, Redblush and Star Ruby). Marsh SL being the first grapefruit variety without seeds is the most cultivated variety in the world.

Besides their nutritive potential, grapefruit may be beneficial in regard to human health. For example, naringenin, an antioxidant which gives grapefruit its bitter taste, can do the same job as two separate drugs currently used to manage Type 2 diabetes. Naringenin helps to increase the body’s sensitivity to insulin. It also helps sufferers maintain a healthy weight, which is a vital part of diabetes treatment. Grapefruit possesses a number of components such as carbohydrates, lipids, vitamins, minerals, flavonoids, coumarins, and hydroxycinnamic acids. Some studies have suggested valuable effects regarding cardiac diseases, obesity, diabetes, bone quality, and urinary tract infections (Adeneye 2008, Diaz-Juárez *et al.* 2009, Devhim *et al.* 2008, and Oyelami *et al.* 2005).

Grapefruit is the most tolerant citrus species to dry warm, semi-tropical humid and tropical climatic conditions (Reuther 1973). There are numerous publications that describe

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the plant and fruit characteristics of many grapefruit cultivars (Saunt 1990, da Graca *et al.* 2004). However, the behavior of these cultivars under sub-tropical conditions of north Indian conditions has not been extensively studied. Keeping in view the importance of grapefruit in human nutrition, the present investigation was carried out with the objective to evaluate grapefruit cultivars for production and quality characteristics in order to identify best suited cultivar(s) for dry sub-tropical climate of northern India.

MATERIALS AND METHODS

One-year-old budlings of six cultivars of grapefruit budded on Jatti khatti rootstocks were planted in filed evaluation block of the Division of Fruits and Horticultural Technology, IARI, New Delhi during 2005. Three pigmented cultivars (Redblush, Foster and Star Ruby) and three white grapefruit cultivars (Imperial, Marsh SL, and Duncan) were used for this study. Plants of these cultivars were spaced at 4 m × 4 m apart. The experimental site falls under trans-gangetic plains of agro-climatic zones of India located at 77°12 'E longitude, 28°40 'N latitude and an altitude of 228.6 m above mean sea level. It has typical subtropical climate characterized by hot and dry summer followed by cold winter. May and June are the hottest months with the maximum temperature ranging between 41 to 44 °C, and December and January are coolest months, with the minimum temperature ranging between 3 to 7 °C. The experimental plants were applied 30 kg farmyard manure, 300 g N, 200 g P₂O₅ and 300 g K₂O/tree/year. Other recommended cultural operations were carried out uniformly. Data were recorded on yield and quality of fruits during 2009, 2010, 2011. During three years, fruits were harvested at maturity and total yield were recorded. For quality analysis, 20 fruits were sampled from each cultivar, and quality characteristics were evaluated including seeds/fruit, peelthickness, fruit weight, fruit size and juice content. Juice was filtered through filter paper, thereafter, juice samples were studied to determine the following parameters; titratable acidity (% of citric acid) using N/10 NaOH and phenolphthalein as indicator, total soluble solids (TSS) using digital refractometer, and ascorbic acid (mg/100 ml of juice.) using a dye (2, 6-dichlorophenol indophenol) according to the standard method (Rangana 1986)). Ferric reducing antioxidant power (FRAP) was performed according to the procedure described by Benzie and Strain (1996). Results were expressed in terms of μ mol Trolox eq/g. The experiment was conducted in randomized block design with 4 replications. Statistical analysis was performed using analysis of variance followed by Duncan's multiple range test (DMRT) using SAS package. P values ≤ 0.05 were considered as significant.

RESULTS AND DISCUSSION

Grapefruit cultivars differed significantly with respect to yield and fruit weight (P ≤ 0.05). Mean fruit yield was

found the highest (31.48 kg/tree) in Imperial followed by Foster (23.43 kg/tree) which was at par with Redblush, Star Ruby and Marsh SL (Fig 1). In this study except Duncan, all other cultivars surpassed the normal yield obtained in commercial grapefruit orchards in humid tropical conditions in Mexico (Sagaroa 2006) indicating that some grapefruit cultivars could be produced commercially in subtropical regions of India. Furthermore, heaviest fruit (414.01 g) was recorded in Foster which did not have significant edge over Imperial (406.90 g) and Duncan (403.19 g). The lowest fruit weight (282.89 g) was weighed in Redblush which was statistically at par with Star Ruby and Marsh SL. These weights are lower than those reported in Mexico where most cultivars had more than 450 g fruit weight (Beerra-Rodrigue and Medina-Urrutia 2008). We categories grapefruit cultivars in two groups based on fruit weight 1. Large size

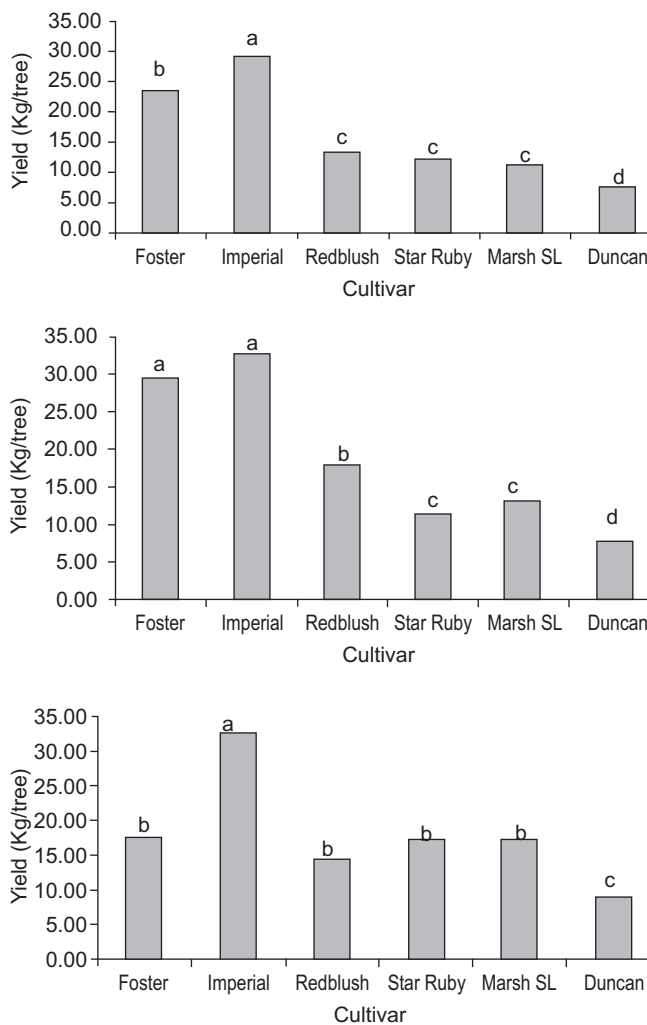


Fig 1 Yield of different cultivars of grapefruit grown under subtropical conditions in years 2009 (A), 2010 (B) and 2011 (C). Each data represent the mean value of four samples. Means with the same letters are not significantly differed at P = 0.05 (DMRT).

fruit (> 400 g); Imperial, Foster and Duncan, 2. Medium size fruit (200-300 g); Redblush, Star Ruby and Marsh SL.

Mean juice content also varied significantly among the cultivars and Duncan and Marsh SL had the highest juice recovery of juice (50.00%) which was not differed significantly with Redblush (46.91%) ($P \leq 0.05$). The lowest juice recovery was found in Foster and Imperial (Table 1). The juice content under subtropical conditions, compared satisfactorily with fruit from other countries such as Brazil; 37.6-39.7% juice (Donadio *et al.* 1996), Mexico; 24.1-42.4% juice (Beerra-Rodrigue and Medina-Urrutia 2008). Fruit size was also differed significantly among different cultivars

(Table 2) the maximum fruit length (8.91 cm) was measured in Foster followed by Duncan (8.56 cm) and Imperial (8.49 cm). However, minimum fruit length (7.77 cm) was recorded in Redblush which did not differ significantly with Marsh SL (7.79 cm). Almost similar trend was noticed with regard to fruit width. The maximum mean fruit width (9.94 cm) was recorded in Duncan which was statistically at par with Foster and Imperial. The minimum fruit width was found in Redblush (8.64 cm). These results confirming previous reports in where variation in shape and size, juice content in different citrus cultivars was reported in different regions (Costa *et al.* 2009, Kumar *et al.* 2010).

Table 1 Fruit weight and juice content of different cultivars of grapefruit grown under subtropical conditions

Cultivar	Fruit weight (g)				Juice (%)			
	2009	2010	2011	Mean	2009	2010	2011	Mean
Foster	408.67 ^b	384.27 ^b	449.10 ^a	414.01 ^a	45.33 ^b	36.77 ^c	44.87 ^c	42.32 ^c
Imperial	430.77 ^a	416.90 ^a	373.00 ^c	406.89 ^a	39.73 ^c	43.63 ^d	42.93 ^d	42.10 ^c
Redblush	303.00 ^c	310.20 ^c	235.47 ^f	282.89 ^b	45.23 ^b	47.43 ^{cb}	48.07 ^b	46.91 ^{ba}
Star Ruby	294.10 ^c	297.67 ^c	263.80 ^e	285.19 ^b	43.77 ^b	45.67 ^{cd}	46.10 ^c	45.18 ^{bc}
Marsh SL	272.93 ^d	277.77 ^d	303.07 ^d	284.59 ^b	50.17 ^a	48.40 ^b	51.32 ^a	49.96 ^a
Duncan	400.67 ^b	401.33 ^a	407.57 ^b	403.19 ^a	48.97 ^a	51.00 ^a	50.00 ^a	49.99 ^a
LSD ≤ 0.05	12.66	16.27	12.86	18.36	2.81	2.51	1.88	4.35

Each data represent the mean value of 20 samples. Means with the same letters are not significantly differed at $P \leq 0.05$ (DMRT).

Table 2 Fruit length and width of different cultivars of grapefruit grown under subtropical conditions

Cultivar	Fruit length (cm)			Mean	Fruit width (cm)			Mean
	2009	2010	2011		2009	2010	2011	
Foster	8.70 ^a	8.78 ^a	9.24 ^a	8.91 ^a	9.67 ^a	9.83 ^a	9.62 ^{ba}	9.71 ^a
Imperial	8.61 ^{ba}	8.48 ^b	8.37 ^c	8.49 ^b	9.61 ^a	9.76 ^a	9.57 ^b	9.65 ^a
Redblush	8.43 ^c	7.46 ^d	7.42 ^e	7.77 ^{cd}	8.62 ^c	8.64 ^d	8.67 ^d	8.64 ^c
Star Ruby	7.53 ^e	7.52 ^d	7.51 ^e	7.52 ^d	8.84 ^b	8.80 ^c	8.86 ^{dc}	8.83 ^b
Marsh SL	7.82 ^d	7.77 ^c	7.79 ^d	7.79 ^c	8.82 ^b	8.97 ^b	9.04 ^c	8.95 ^b
Duncan	8.55 ^b	8.52 ^b	8.60 ^b	8.56 ^b	9.67 ^a	9.76 ^a	9.79 ^a	9.74 ^a
LSD ≤ 0.05	0.11	0.18	0.10	0.19	0.16	0.14	0.20	0.13

Each data represent the mean value of 20 samples. Means with the same letters are not significantly differed at $P = 0.05$ (DMRT).

Table 3 Peelthickness and numbers of seeds in different cultivars of grapefruit grown under subtropical conditions

Cultivar	Peelthickness (mm)			Mean	Seeds			Mean
	2009	2010	2011		2009	2010	2011	
Foster	5.20 ^e	5.30 ^c	5.40 ^c	5.30 ^e	49.67 ^a	41.67 ^b	42.00 ^a	44.44 ^a
Imperial	7.03 ^a	6.90 ^a	7.03 ^a	6.99 ^a	44.67 ^b	54.00 ^a	34.33 ^b	44.33 ^a
Redblush	6.13 ^c	6.27 ^b	6.20 ^b	6.20 ^{cd}	4.00 ^d	3.33 ^{cd}	2.00 ^c	3.11 ^c
Star Ruby	6.47 ^b	6.17 ^b	6.40 ^b	6.34 ^{cb}	5.33 ^d	5.00 ^d	3.33 ^c	4.56 ^c
Marsh SL	5.73 ^d	6.27 ^b	5.73 ^c	5.91 ^d	3.33 ^d	1.67 ^e	4.00 ^c	3.00 ^c
Duncan	6.50 ^b	6.63 ^a	6.53 ^b	6.56 ^b	33.33 ^c	30.33 ^c	34.67 ^b	32.78 ^b
LSD ≤ 0.05	0.33	0.27	0.38	0.30	4.87	3.23	3.12	8.43

Each data represent the mean value of 20 samples. Means with the same letters are not significantly differed at $P \leq 0.05$ (DMRT).

Table 4 Total soluble solids and acidity contents in different cultivars of grapefruit grown under subtropical conditions

Cultivar	TSS (%)			Mean	Acidity (%)			Mean
	2009	2010	2011		2009	2010	2011	
Foster	8.69 ^d	9.37 ^c	8.50 ^{ba}	8.85 ^{bc}	1.03 ^b	0.87 ^c	0.91 ^b	0.94 ^{bac}
Imperial	9.60 ^c	8.90 ^d	8.80 ^a	9.10 ^b	0.85 ^c	0.68 ^d	1.03 ^a	0.85 ^{bc}
Redblush	10.23 ^b	9.57 ^{bc}	8.70 ^a	9.50 ^a	1.16 ^a	1.10 ^a	0.90 ^b	1.05 ^{ba}
Star Ruby	8.57 ^d	9.90 ^{ba}	8.00 ^b	8.82 ^{bc}	0.78 ^c	0.80 ^{bc}	0.81 ^c	0.79 ^c
Marsh SL	9.53 ^c	9.97 ^a	9.10 ^a	9.53 ^a	0.78 ^c	0.90 ^b	0.74 ^c	0.81 ^c
Duncan	10.57 ^a	9.57 ^{bc}	8.53 ^{ba}	9.56 ^a	1.19 ^a	1.06 ^a	1.01 ^a	1.09 ^a
LSD \leq 0.05	0.26	0.34	0.67	0.36	0.10	0.12	0.08	0.21

Each data represent the mean value of 20 samples. Means with the same letters are not significantly differed at $P \leq 0.05$ (DMRT).

Table 5 Ascorbic acid content and anti-oxidant (AOX) activity in different cultivars of grapefruit grown under subtropical conditions

Cultivar	Ascorbic acid (mg/100 ml juice)			Mean	AOX activity (μ mol Trolox eq/g)			Mean
	2009	2010	2011		2009	2010	2011	
Foster	54.17 ^b	60.38 ^c	34.30 ^d	49.61 ^b	4.34 ^d	4.31 ^d	4.27 ^d	4.31 ^d
Imperial	42.71 ^c	42.60 ^e	42.00 ^a	42.44 ^c	5.59 ^a	5.52 ^a	5.59 ^a	5.56 ^a
Redblush	62.98 ^a	63.28 ^b	40.30 ^{ba}	55.52 ^a	4.52 ^c	4.56 ^c	4.52 ^c	4.53 ^c
Star Ruby	43.45 ^c	47.01 ^d	38.27 ^{bc}	42.91 ^c	4.04 ^e	4.05 ^e	4.07 ^d	4.05 ^f
Marsh SL	65.49 ^a	65.56 ^a	38.53 ^{bc}	56.53 ^a	5.05 ^b	5.09 ^b	5.10 ^b	5.08 ^b
Duncan	38.93 ^d	36.30 ^f	36.63 ^{dc}	37.29 ^c	4.16 ^e	4.16 ^e	4.16 ^{ed}	4.16 ^e
LSD \leq 0.05	3.64	2.14	3.40	6.52	0.13	0.11	0.14	0.06

Each data represent the mean value of 20 samples. Means with the same letters are not significantly differed at $P \leq 0.05$ (DMRT).

Grapefruit cultivars also differed significantly ($P \leq 0.05$) with regard to peel thickness and numbers of seeds/fruit (Table 3). Grapefruit cultivar Imperial had thickest peel (6.99 mm) followed by Duncan (6.63 mm) which was statistically at par with Star Ruby and Redblush. The lowest peel thickness was found in Foster (5.30 mm). Whereas, numbers of seeds/fruit was recorded the highest in Foster and Imperial (> 44 seeds/fruit) followed by Duncan (> 32 seeds/fruit). Other cultivars like Marsh SL, Star Ruby and Redblush seems to be seedless and had less than 5 seeds/fruit. Quality parameters, viz. TSS, acidity, ascorbic acid content and anti-oxidant activities were also differed significantly among grapefruit cultivars (Table 4 and 5). Mean TSS was recorded higher in Duncan (9.56%) which was at par with Marsh SL (9.53%) and Redblush (9.50%). The lowest was found in Star Ruby (8.82%) which did not differ significantly with Foster. Significantly lower acidity was recorded in Marsh SL (0.81%), Imperial (0.85%) and Foster (0.94%). While maximum acidity was found in Duncan (1.09%) which did not differ significantly with Redblush (1.05%) and Foster (0.94%). Ascorbic acid also varied significantly ($P \leq 0.05$). The higher ascorbic acid content (56.53 mg/100 ml juice) was estimated in Marsh SL followed by Foster (49.61 mg/100 ml juice) which was at par with Imperial and Duncan (37.29 mg/100 juices). Grapefruit cultivars also differed significantly with regard to antioxidant activities (Table 5). The maximum AOX activity (5.56 μ mol

Trolox eq/g) was recorded in Imperial followed by Marsh SL (5.08 μ mol Trolox eq/g) and Redblush (4.53 μ mol Trolox eq/g). While the lowest AOX activities were found in Duncan (4.16 μ mol Trolox eq/g). This result is consistent with previous reports where variation in fruit quality in Valencia orange (Zambrano *et al.* 2001), sweet orange cultivars (Dubey 2000), mandarin cultivars (Dubey *et al.* 2004) and sweet orange cultivar (Kaul *et al.* 2002), Malta collections (Dubey *et al.* 2012). Goulas and Manganaris (2012) also reported variation in ascorbic acid content, as well as higher antioxidant potency in different citrus species and hybrids. Similarly Kelebek (2010) found variation in antioxidant activities of different cultivars of grapefruit.

Based on the above results, we could recommend grapefruit cultivars Marsh SL and Redblush for cultivation under north Indian conditions. Although Imperial had higher seeds but due to high yield potential and high antioxidant enzymes activities, this cultivar can also be grown under North Indian conditions. Further research is needed to ascertain limonene and narigin contents in these promising cultivars under subtropical conditions.

REFERENCES

- Adeneye A A. 2008. Hypoglycemic and hypolipidemic effects of methanol seed extract of *Citrus paradisi* Macfad (Rutaceae) in alloxan-induced diabetic Wistar rats. *Nig. Q. J. Hosp. Med.* **18**: 211–5.

- Barry G H and Veldman F J. 1996. Performance of nine grapefruit (*Citrus paradisi* Macf.) cultivars under hot, subtropical southern African conditions. *Proc Int Soc Citriculture* 1: 113–5.
- Beerra-Rodrigue S and Medina-Urrutia V M. 2008. Performance of various grapefruit (*Citrus paradisi* Macf.) and pummelo (*C. maxima* Merr.) cultivars under the dry tropic conditions of Mexico. *Euphytica* 164: 27–36.
- Benzie I F F and Strain J J. 1996. Ferric reducing ability of plasma (FRAP) as a measure of antioxidant power: The FRAP assay. *Analytical Biochemistry* 239: 70–6.
- Costa C, Menesatti P, Paglia G, Pallottino F, Aguzzi J, Rimatori V, Russo G, Recupero S and Recupero G R. 2009. Quantitative evaluation of Tarocco sweet orange fruit shape using optoelectronic elliptic Fourier based analysis. *Postharvest Biology and Technology* 54: 38–47.
- da Graca J V and Sauls J W. 2000. Texas citriculture—past and present. *Proc Int Soc Citriculture* 1: 451.
- da Graca J V, Louzada E S and Sauls J W. 2004. The origins of red pigmented grapefruits and the development of new varieties. *Proc Int Soc Citriculture* 1: 369–74.
- Devhim F, Mndadi K, Patil B S and Faraji B. 2008. Grapefruit pulp increases antioxidant status and improves bone quality in orchidectomized rats. *Nutrition* 24: 1 039–44.
- Donadio L C, Banzatto D A, Sempionato O R and Enciso C R. 1996. Grapefruit cultivar evaluation. *Pro. Int Soc Citriculture* 1: 207–9.
- Dubey A K. 2000. Comparative performance of certain Sweet orange (*Citrus sinensis* (L.) Osbeck) cultivars at foothills situation of Arunachal Pradesh. *Progressive Horticulture* 32: 153–8.
- Dubey A K, Rai M and Upadyaya R C. 2004. Varietal evaluation of mandarin orange for mid altitude of Arunachal Pradesh. *International Journal of Tropical Agriculture* 22: 81–93.
- Dubey A K, Srivastav M, Awasthi, O P and Verma M K. 2012. Superior sweet orange accessions for quality and yield. Abs, *National dialogue on citrus improvement, production and utilization*, 27-29 February 2012, p 46.
- Goulas V and Manganaris G A. 2012. Exploring the phytochemical content and the antioxidant potential of citrus fruits grown in Cyprus. *Food Chemistry* 131: 139–47.
- Human C F, Steenekamp P J, Snyman C J and Maritz J G J. 1996. Evaluation of grapefruit and Valencia cultivars in South Africa. *Proc Int Soc Citriculture* 1: 231–3.
- Kelebek H. 2010. Sugar, organic acid, phenolic compositions and antioxidant activity of grapefruit (*Citrus paradise*) cultivars grown in Turkey. *Industrial Crops and Product* 32: 269–74.
- Kaul M K, Bhatnagar P and Kumar M. 2002. Varietal evaluation trial in *Citrus sinensis* (Osbeck). *Indian Journal of Citriculture* 1: 3–5 .
- Kumamoto J, Scora R W, Lawton H W and Clerx W A. 1987. Mystery of the forbidden fruit: historical epilogue on the origin of grapefruit, *Citrus paradisi* (Rutaceae). *Economic Botany* 41: 97–107.
- Kumar P S, Devi P, Choudhary V K and Kanwat M. 2010. Evaluation of different mandarin, sweet orange, rootstock species and cultivars under mid hill conditions of Arunachal Pradesh. *Indian Journal of Horticulture* 67: 433–40.
- Oyelami O A, Agbakwuru E A, Adeyemi L A and Adedeji G B. 2005. The effectiveness of grapefruit (*Citrus paradisi*) seeds in treating urinary tract infections. *Journal of Alternative Complementary Medicine* 11: 369–71.
- Rangana S. 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, 2nd edition, p 1 103. McGraw Hill Publishing Co Ltd, New Delhi.
- Reuther W. 1973. Climate and citrus behaviour. (In) *The Citrus Industry*, vol 3, Reuther W, Webber H J, Batchelor L (Eds). Division of Agricultural Science, University of California, Berkeley.
- Sagaroa. 2006. Sistema de informacion agropecuaria de consulta. SIACON.
- Saunt J. 1990. The grapefruit. (In) *Citrus Varieties of the World*, p 128. Truman K (Ed). Sinclair International Limited, England.
- Scora R W, Kumamoto J, Soost R K and Nauer E M. 1982. Contribution to the origin of grapefruit, *Citrus paradisi* (Rutaceae). *Systematic Botany* 7: 170–7.
- Yamamoto M, Kobayashi S, Nakamura Y and Yamada Y. 1993. Phylogenetic relationships of Citrus revealed by RFLP analysis of mitochondrial and chloroplast DNA. *Japan Journal of Breeding* 43: 355–65
- Zambrano J, Quintero I, Alvarez R, Hortegano R and Saenz M. 2001. Evaluation of fruit quality of ‘Valencia’ oranges in three altitudinal levels in Trujillo State, Venezuela. [Spanish] *Agronomia Tropical* (Maracay). 51 : 107–17.