DOI : 10.5958/0974-0112.2016.00044.X

Indian J. Hort. 73(2), June 2016: 183-187

Nutritional composition in fruits of gynodioecious papaya genotypes

Jai Prakash[*], Vartika Srivastava[**], A.K. Goswami, Kanhaiya Singh and A.K. Singh

Division of Fruits & Horticultural Technology, ICAR-Indian Agricultural Research Institute, New Delhi 110012

ABSTRACT

The experiment was carried out during 2014-15 to find out the nutritive value of female and hermaphrodite fruits of gynodioecious genotypes of papaya fruits to know their nutrient status. The fruits of five gynodioecious genotypes, namely, P-7-2, P-9-5, P-7-9, P-7-15 and commercial hybrid Red Lady, were evaluated for moisture content, protein, fibre, lycopene, β-carotene, phenols, flavonoids, and various antioxidant activities The total moisture per cent was found minimum (85.62) in P-7-9 followed by P-7-15 and P-9-5 (86.69). The maximum protein (8.71% on DW basis) was in P-9-5 and P-7-9. The lower moisture per cent, fibre, β-carotene, total phenols (31.79 mg GAE/100 g), flavonoids (31.75 mg QE/100 g) and free radical scavenging activity DPPH (0.27 µmol TE/g) were found significantly higher in hermaphrodite fruits of all gynodioecious genotypes. However, protein, lycopene and total carotene were observed higher in female fruits. Fruits of P-9-5 was found with highest amount of nutritive values, particularly total phenols, flavonoids and free radical scavenging activity DPPH followed by P-7-9, and P-7-15.

Key words: Fibre, flavonoids, gynodioecious lines, nutritive value, papaya.

INTRODUCTION

Papaya (*Carica papaya* L.), is one of the major fruit crops cultivated in the tropical and subtropical region of the globe and 4th most important fruit crops of India. The area and production in the last few years have increased sharply due to its wider adaptability and increased demand for fruits among the consumers. It has tremendous yielding potential due to precocious bearing and indeterminate growth habit with simultaneous vegetative growth, flowering and fruiting (Prakash *et al.*, 7). Papaya is a fruit that is well known for its nutritional and medicinal values for vitamin A, vitamin C, potassium, folate, niacin, thiamine, riboflavin, iron, and calcium plus fibre. Papaya has become an important part of the diet in most of the Indians and also in other tropical countries. The protein-digesting enzyme 'papain' is very similar to human stomach pepsin.

Area under papaya is slowly increasing for both fruit and papain extraction in India. The grower is thus confronted with the problem of selecting the right type of plant material for commercial plantation; but unfortunately one cannot identify the productive and unproductive plants at nursery stage. The papaya generally flowers 75 to 135 days after transplanting and identification of the sex of the seedling is normally possible only after flowering. In earlier studies, it has been observed that the growth of hermaphrodite plants is being faster compared to the female plants. In subtropical region, the dioecious varieties are preferred in over gynodioecious once due to higher number of stable female plants. Conversely in the tropical areas, gynodioecious varieties are preferred because of their high yielding capacity. Consumer preference has been also noticed for the hermaphrodite fruits over fruit developed from female plants. Therefore, present investigation was carried out to know the nutrient content of fruit borne on female and hermaphrodite plants in five gynodiecious genotypes.

MATERIALS AND METHODS

The present study was conducted at Division of Fruits and Horticultural Technology, ICAR-IARI, New Delhi. Total five gynodioecious genotypes, *i.e.* P-7-2, P-9-5, P-7-15, P-7-9 and commercial hybrid Red Lady were grown and maintained under net-house with growing conditions and fruits uniform harvested at same stage of maturity (fully ripe) were subjected for the analysis. Fruits of female and hermaphrodite plants were harvested at the colour break to ripe stages from all the five genotypes. The homogenized composite samples were prepared and stored in airtight polybag in desiccators for further use. Fruit moisture content was determined by gravimetric measurement. Total nitrogen content was determined by the Kjeldahl method (AOAC, 1) using an autoanalyzer. Protein was calculated as Kjeldahl nitrogen × 6.25. Fibre was determined by grinding the dried samples to pass a 1.0 mm screen, and extracting with ether to remove excess fat. Samples were then digested in dilute sulphuric

*Corresponding author's E-mail: singhjai2001@rediffmail.com
**ICAR-NBPGR, New Delhi 110012

acid, filtered, digested in dilute sodium hydroxide (Fisher Scientific, Pittsburg, PA), and filtered again. The residue was washed, dried, weighed, ignited, and reweighed. Fibre was calculated from the loss on ignition of the residue was calculated using the following formula: FS = $(F_1 - F_2)$/ F0 × 100, Where, F_1 = Final weight of the sample (digested and oven dried), F_2 = Weight of the sample after ashing, F_0 = Initial weight of the sample (dried and finely crushed) (AOAC, 1). Papaya samples were extracted and analyzed for β-carotene and total carotene contents using the methods of Bushway *et al*. (4). Total phenols were estimated spectrophotometrically using Folin-Ciocalteu reagent (FCR) as described by Heinonen *et al.* (5). To 100 µl of extract (80% ethanol) 2.9 ml of deionized water, 0.5 ml of Folin-Ciocalteu reagent (1N) and 2.0 ml of 20% Na_2CO_3 solution were added. The mixture was allowed to stand for 30-45 min. and absorption was measured at 760 nm OD and at 750 nm. Results were expressed as gallic acid equivalent (mg GAE /100 g. Total flavonoids were analyzed using aluminium chloride method described by Zhishen *et al.* (9) and the results were expressed as quercetin equivalent (mg QE/100 g). For the estimation of cupric reducing antioxidant power (CUPRAC), standard method developed by Apak *et al.* (2) was followed and the results were expressed as µmol TE /g, using molar absorptivity of Trolox as 1.67×10^4 l/ mol/ cm. Free radical scavenging activity using DPPH assay performed as described by Brand-Williams *et al.* (3). Results were expressed as µmol TE/g. Data recorded for the different fruit characters were subjected to factorial randomised block design for analysis. The differences exhibited by the genotypes and both female and hermaphrodite sex for various characters were tested for the significance using the one way ANOVA using Web Agri Stat Package (WASP) 2 (http://icargoa.res.in/wasp/index.php).

RESULTS AND DISCUSSION

It is evident from the data presented in the Table 1 that genotypes and fruits of both female and hermaphrodite sex types had significant influence on the moisture, protein and fibre content in fruits. Red Lady had maximum moisture per cent (88.12) among all the genotypes followed by P-7-2 (87.87%), whereas minimum (85.62) was observed in P-7-9 followed by P-7-15 and P-9-5 (and 86.69%) among the studied genotype. Significant differences were observed in the moisture content of the fruits of female and hermaphrodite plants. The average moisture per cent (87.18) was found higher in female fruits and 86.69 per cent in hermaphrodite fruits. As regards genotypes and types of sex, maximum moisture content (88.63%) was found in female fruits of hybrid Red Lady followed by female fruits of P-7-2 (88.40%), while minimum moisture per cent (85.46 & 85.78) in hermaphrodite and female fruits of P-7-9. The lower moisture content in fruit pulp in P-7-9 and P-9-5 may be attributed to genetic makeup of these genotypes and it also indicated as higher level of nutrition in their fruits.

Maximum protein (8.71%) was found in genotypes P-7-9 and P-9-5 followed by P-7-15 (8.40%) and minimum (7.2%) in P-7-2. Fruits of female plants had highest quantity of protein (8.89%) as compared to hermaphrodite fruits (7.57%). Interaction between genotypes and sex were found to be quite superior and highest protein content (11.59%) was found in hermaphrodite fruits of genotype P-7-5 and lowest (5.81%) in female fruits of P-7-2 genotype. However, maximum fibre content (5.56%) was recorded in genotype P-7-9 followed by Red Lady (5.38%) and

Table 1. Moisture, protein and fibre content in fruits of gynodioecious papaya genotypes.

Treatment	Moisture (%)			Protein (%) in 100 g fruits DW basis			Fibre (%) in 100 g fruits DW basis		
	F	H	Mean	F	H	Mean	F	H	Mean
P-7-2	88.40	87.35	87.87	5.81	8.71	7.26	4.57	4.93	4.75
P-9-5	86.79	86.57	86.67	8.72	8.70	8.71	4.45	5.24	4.85
P-7-9	85.78	85.46	85.62	8.70	8.71	8.71	5.22	5.90	5.56
P-7-15	86.31	86.48	86.40	9.64	7.15	8.40	4.07	4.10	4.09
Red Lady	88.63	87.62	88.12	9.59	6.60	8.09	5.40	5.37	5.38
Mean	87.18	86.69		8.63	7.87		4.74	5.11	
LSD at 5%									
Genotype	0.59			1.98			0.59		
Sex	0.38			1.25			0.37		
Interaction (A × B)	0.83			2.81			0.84		

minimum (4.09%) was found in genotype P-7-9. Fruits of hermaphrodite plant have maximum (5.11%) fibre content as compared to female fruits (4.74%). Interaction between genotype and sex showed maximum (5.90%) fibre content in hermaphrodite fruits of genotype P-7-2, while minimum (4.07%) was also found in the same sex type in genotype P-7-9. The higher level of fibre in hermaphrodite fruits might be due to lower level of moisture content in fruit pulp compared to female fruits. Plant-to-plant and female to hermaphrodite variation even within a particular papaya genotype grown under the same conditions is common and could possibly explain this variation observed between the fruits of both sex types in the gynodioecious lines.

The data presented in Table 2 revealed significant differences in lycopene, total carotene and β-carotene contents among different gynodioecious genotypes and fruits from both sexes. The maximum lycopene (2.02 mg/100 g) was observed genotype P-7-15, while least (0.71 mg/100 g) was recorded in P-9-5 genotype. Fruits of female plant contains higher amount of lycopene (1.75 mg/100 g) as compared to hermaphrodite sex (1.25 mg/100 g). Interaction between genotypes and sex observed maximum amount of lycopene (2.21 mg/100 g) in hermaphrodite fruits of Red Lady genotype followed by 2.09 mg/100 g, while minimum (0.75 mg) was found in hermaphrodite fruits of Red Lady. Maximum quantity of total carotene (14.76 mg/100 g) was recorded in P-7-15 genotype followed by P-9-5 (11.80 mg/100 g) and minimum (5.16 mg/100 g) was observed in genotype P-7-2. However, higher amount of total carotene (10.58 mg/100 g) was found in female fruits as compared to hermaphrodite fruits (9.26 mg/100 g). The interaction of genotype and sex type, maximum amount of total carotene (17.83 mg/100 g) was found in female fruits of P-7-15 followed by in hermaphrodite fruits of P-9-5 (12.44 mg/100 g) and minimum (4.90 mg/100 g) in hermaphrodite fruits of P-7-2 genotype. The beta carotene content in papaya varies from genotype to genotype and type of sex form of the fruit. Among the genotypes, maximum β-carotene content (3.07 mg/100 g) was recorded in Red Lady, which was significantly higher than the rest of the genotypes. As regards beta carotene content in fruits of both sex forms, maximum (1.63 mg/100 g) was observed in hermaphrodite fruits as compared to female fruits (1.22 mg/100 g).Interaction between genotypes and sex forms, hermaphrodite fruits of Red Lady contains highest amount of β-carotene (3.69 mg/100 g), while minimum (0.14 mg/100 g) was found in female fruits of genotype P-7-2. The higher amount of beta-carotene in Red Lady might be due to red pulp colour of the fruits. Plants contain many natural antioxidants such as carotenoids, vitamins, and endogenous metabolites (Rice-Evans and Miller, 8).

Analysis of the data exhibited in Table 3 shows that the genotype and sex form had significant difference as an individual as well as in combination for the total phenols, total flavonoids and DPPH activity of papaya fruits. Advance line papaya P-9-5 contains highest total phenols (39.13 mg GAE/100g) followed by P-7-9 (24.43 mg GAE/100 g), whereas lowest total phenols content (9.46 mg GAE/100 g) in Red Lady among the genotypes. Between the fruits of both sex forms, hermaphrodite fruits have highest amount of total phenols (31.79 mg GAE/100 g) as compared to female fruits (15.67 mg GAE/100 g). Among interaction of genotype and sex type, the maximum amount of total phenols (47.33 mg GAE/100 g) was found in hermaphrodite fruits of

Table 2. Lycopene, total carotene and β-carotene contents in fruits of gynodioecious papaya genotypes.

Treatment	Lycopene (mg/100 g pulp FW)			Total carotenoids (mg/100 g pulp FW)			B-carotene (mg/100 g pulp FW)		
	F	H	Mean	F	H	Mean	F	H	Mean
P-7-2	1.82	0.95	1.39	5.41	4.90	5.16	0.29	0.14	0.21
P-9-5	0.80	0.61	0.71	11.17	12.44	11.80	0.54	0.59	0.57
P-7-9	1.80	2.00	1.90	9.97	7.22	8.59	0.35	1.02	0.69
P-7-15	2.09	1.95	2.02	17.83	11.69	14.76	2.46	2.70	2.58
Red Lady	2.21	0.75	1.48	8.53	10.05	9.29	2.45	3.69	3.07
Mean	1.75	1.25		10.58	9.26		1.22	1.63	
LSD at 5%									
Genotype	0.99			3.34			0.51		
Sex	0.62			2.11			0.32		
Interaction (A × B)	1.39			4.73			0.72		

Table 3. Total phenols, flavonoids content and DPPH activities in fruits of gynodioecious papaya genotypes.

Treatment	Total phenols (mg GAE /100 g)			Total flavonoids (mg QE /100 g)			DPPH (μmol TE/g)		
	F	H	Mean	F	H	Mean	F	H	Mean
P-7-2	9.90	33.66	21.78	10.44	11.06	10.75	0.02	0.22	0.12
P-9-5	33.47	47.33	39.13	33.40	47.55	40.48	0.20	0.34	0.27
P-7-9	15.42	33.45	24.43	28.37	33.58	30.98	0.20	0.04	0.12
P-7-15	10.72	36.74	23.84	36.11	37.84	36.98	0.03	0.04	0.04
Red Lady	11.4	8.12	9.46	25.91	28.69	27.30	0.02	0.03	0.03
Mean	15.67	31.79		26.85	31.75		0.09	0.13	
LSD at 5%									
Genotype	2.28			3.45			0.11		
Sex	1.44			2.18			0.07		
Interaction (A × B)	3.22			4.87			0.15		

P-9-5 followed by fruits of P-7-9 (36.74 mg GAE/100 g) and least amount was observed in hermaphrodite fruits of Red Lady (8.12 mg GAE/100 g) followed by female fruits of P-7-2 (9.90 mg GAE/100 g) with a non-significant difference. Maximum amount of total flavonoids (40.48 mg QE/100 g) was recorded in genotype P-9-5 followed by P-7-15 (36.98 mg QE/100 g) and minimum in Red Lady (9.46 mg QE/100 g). Sex forms of fruits also influenced total flavonoids contents in papaya fruits. Maximum amount of total flavonoids (31.75 mg QE/100 g) was found in hermaphrodite fruits than the female fruits (26.85 mg QE/100 g). Interaction between genotype and sex type were found to be quite superior and highest amount of total flavonoids (47.55 mgQE/100 g) were found in hermaphrodite fruits of genotype P-9-5 followed by (37.84 mg QE/100 g) in hermaphrodite fruits of P-7-15, while minimum (10.44 mg QE/100 g) in female fruits of P-7-2 genotype.

Radical scavenging capacity was assessed by using DPPH (2,2-diphenyl-1-picrylhydrazyl) assay. The IC50 values are expressed as μmol TE/g and represent the concentration of extracts that is required for 50% of free radicals inhibition. Genotypes of papaya vary for the DPPH content of fruits. Maximum DPPH (0.27 μmol TE/ g) was recorded in genotype P-9-5 followed by (0.12 μmol TE/g) in P-7-2 and (0.12 μmol TE/g) P-7-9 genotypes. Sex forms of papaya also vary for the DPPH content of fruits and maximum amount (0.13 μmol TE/ g) was found in hermaphrodite fruits compare to female fruits (0.09 μmol TE/ g). As regards combination of genotype and sex form in papaya, the highest amount of DPPH (0.34 μmol TE/ g) was found in hermaphrodite fruits of P-9-5 genotype, while minimum (0.02 μmol TE/g) was recorded in female fruits of P-7-2 and P-7-15 genotypes.

The high level of antioxidants and its activity in terms of DPPH among the hermaphrodite fruits of gynodioecious genotype might be due to late flowering and less fruit set which provide extra space to accumulate higher level of photosythiates and later they might be contributing with enhanced level of antioxidants in hermaphrodite fruit plants. The phytochemicals in fruits responsible for antioxidant activity can largely be attributed to phenolic compounds such as anthocyanins and carotenoids, and to other flavonoid compounds. Free radical scavenging properties of the phenolic hydroxy groups attached to ring structures are responsible for the strong antioxidant properties of the anthocyanins (Rice-Evans and Miller, 8).

The genotype P-9-5 showed significantly higher values of total phenol, DPPH reduction activity. Red Lady showed significantly higher values of β-carotene. Knowledge gained from this research will be helpful in selecting genotypes showing improved fruit quality (in terms of β-carotene and antioxidant content) and their further utilization in breeding programmes. The observed nutrient content in female and hermaphrodite fruits is useful for both growers and consumers and they have to take the advantage of the finding for selection and purchase of the fruits according to the nutrient content within the gynodioecious varieties and hybrids available in the market. The growers may get better price of the hermaphrodite fruits and consumers may choose it for consumption of high amount of antioxidants.

REFERENCES

1. Anonymous. 1995. Association of Official Analytical Chemists AOAC, *Official Methods*

of Analysis (16th Edn.), AOAC International, Arlington, VA.

2. Apak, R., Guclu, K., Ozyurek, M. and Karademir, S.E. 2004. Novel total antioxidant index for dietary polyphenols and vitamins C and E using their cupric ion reducing capability in the presence of neocuproine: CUPRAC method. *J. Agric. Food Chem.* **52**: 7970-81.

3. Brand-Williams, W., Cuvelier, M.E. and Berset, C. 1995. Use of free radical method to evaluate antioxidant activity. *Lebensm Wiss. Tech.* **28**: 25-30.

4. Bushway, R.J. 1985. Separation of carotenoids in fruits and vegetables by high performance liquid chromatography. *J. Liquid Chrom.* **8**: 1527-47.

5. Heinonen, I.M., Meyer, A.S. and Frankel, E.N. 1998. Antioxidant activity of berry phenolics on human low-density lipoprotein and liposome oxidation. *J. Agric. Food Chem*. **46**: 4107-12. http://icargoa.res.in/wasp/index.php

6. Prakash, J., Singh, N.P. and Sankran, M. 2010. Influence of nutrition and VAM fungi on plant growth parameters, physio-chemical composition of fruit and yield of papaya (*Carica papaya* L.) cv. Pusa Delicious. *Acta Hort.* **851**: 381-84.

7. Rice-Evans, C.A. and Miller, N.J. 1996. Antioxidant activities of flavonoids as bloactive components of food. *Biochem. Soc. Trans.* **24**: 790-95.

8. Zhishen, J., Mengcheng, T. and Jianming, W. 1999. The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chem.* **64**: 555-59.

(Received: April, 2015; Revised; February, 2016; Accepted: March, 2016)