Journal of Spices and Aromatic Crops
Vol. 23 (1) : 17–25 (2014)
www.indianspicesociety.in/josac/index.php/josac

Indian Society for Spices

Variability in quality attributes of paprika and paprika alike chillies (*Capsicum annuum* L.)

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Received 03 April 2013; Revised 09 May 2013; Accepted 17 July 2013

Abstract

An investigation was carried out to assess the variability in paprika alike chillies (26 indigenous germplasm) and paprika lines (18 exotic collections) for yield and quality attributing parameters, which would inturn help in identifying and utilizing the promising lines for crop improvement. Highly significant variation was recorded among the genotypes for yield and quality contributing characters. Kt-Pl-19, Kt-Pl-19 variant–I, ICBD-10, ICBD-8, SSP-1999 and PBC-171, were found promising, while ICBD-10, ICBD-8, ICBD-1, ICBD-11, ICBD-6, ICBD-19, CC-1, EC-171, EC-490, EC-18, EC-6, EC-45, EC-71 and EC-14 proved to be ideal for quality attributes. Based on yield and quality parameters, the genotypes ICBD-10, ICBD-8 and EC-18 were found suitable for paprika industry with high yield (> 850 g plant^{-1}) and high quality attributing characters (> 200 ASTA units and < 0.5% capsaicin). Among the various characters, maximum coefficient of variation (15.25%) was recorded for capsaicin content in both indigenous and exotic germplasm and minimum variation for color value (0.46%) in the indigenous germplasm and weight of pericarp (6.78%) in the exotic collections.

Keywords: capsaicin, color, oleoresin, paprika, paprika alike chillies, yield, quality

Introduction

Capsicum or chilli and paprika (*Capsicum annuum* L.) are native to the tropics and sub-tropics. Both chilli and paprika are largely consumed as vegetable and spice all over the world. The majority of cultivars grown in Asian countries are pungent, while less and non-pungent ones are common in European countries. Three major products traded in the world market are paprika, oleoresin and dried chilli (both in whole and powder form). They are widely used in curry powder, paste, pickles, sauces and ketchups for its characteristic pungency, color and aroma (Shiva *et al.* 2006). International Spice Traders use the term 'Paprika' for non-pungent (sweet) red *Capsicum* powder, which

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is used primarily for its color and flavor in the processed foods. In the Hungarian language, paprika means plants of the genus *Capsicum*. The quality of red chilli powder and paprika products is determined by the visual and extractable color, pungency level and to a lesser degree by nutritional value (Verma 2003). This can be possible when the raw materials are of improved quality, which can only be achieved after developing an improved variety having all the desired quality parameters (Verma & Joshi 2000). The trade and use of paprika powder is on the rise and in India, as yet, there is no spice paprika variety grown commercially to meet the requirement of the industry. However, there are a few indigenous types of chillies, which are akin to paprika with fruits having high color and less pungency such as 'Byadagi chilli' grown in Dharwad district of Karnataka state and Warangal Chappatta (Tomato chilli) grown in Warangal and Khammam districts of Andhra Pradesh, which are identical to paprika types that are grown in Spain and Hungary (Mathew *et al*. 2000; Shiva *et al.* 2008). These chillies are much preferred by oleoresin manufacturers for extraction of paprika alike oleoresin (Mathew *et al*. 2000; John 2000). Presently, paprika cultivation and production is mainly in dry sub-tropical or temperate regions. Realizing the vast potential existing in the country, a progamme to develop suitable paprika varieties initiated in 1988 has resulted in the development of 'Arka Abir' (a selection from Byadagi chillies having high oleoresin and low pungency) from Indian Institute of Horticultural Research (IIHR), Bangalore and 'Kt-Pl-19' (having high color and high oleoresin) from Indian Agricultural Research Institute (IARI), Regional Station, Katrain, Himachal Pradesh. Main traits required for commercial varieties of paprika are high yield, high pigment content and color retention and quality parameters like less or zero pungency level (Verma & Joshi 2000). Performance of Kt-Pl-19 (Total extractable color: 173 -213 ASTA units) and 'Bydagi Chilli' (capsaicin -0.05%; oleoresin- 12%-16% and color value – 157 ASTA units) were reported by John (1995) and Hosamani (2000). However, the information available on variability in the indigenous and exotic germplasm for quality parameters like color, pungency and oleoresin and its attributes like yield and weight of pericarp and their relationships are very scanty. Keeping these points in view, the present study was carried out to assess the variability present in the germplasm of paprika (18 exotic) and paprika alike chillies (26 indigenous) for quality and its contributing characters, which would help in identifying suitable genotypes for crop improvement programs.

Materials and methods

The present investigation was carried out at Indian Institute of Spices Research, Kozhikode (Kerala) during 2004 to 2007. Paprika (exotic) and paprika alike chilly (indigenous) lines collected from various sources [ICBD denotes the indigenous collections of Byadagi Dabbi] through field survey and correspondence were purified initially using insect-proof nylon cage as suggested by Bosland (1993) and the seeds thus collected from each accession were stored separately in butter-paper cover placed in desiccator. The seeds sown in nursery and seedlings were transplanted to pots after one-month under rain-shelter for four seasons (January to June) and the data were pooled and analyzed. The trial was laid out in completely randomized design with 26 indigenous germplasm (paprika alike chillies) and 18 exotic collections (paprika), replicated thrice. Single plant per plot was maintained with ten plants per replication.

Observations on weight of pericarp per fruit on fresh weight basis and yield per plant were recorded from 10 pots/plants in each replication for each genotype for four seasons (2004 to 2008). The yield was recorded from three pickings at an interval of 10 days and totaled for each genotype. Ripened red fruits were harvested and dried in controlled condition. Dried pods were powdered and used for analyses. The total extractable color of the fruit pericarp was analyzed by American Spice Trade Association (ASTA) method using a UV-visible spectrophotometer at 460 nm using acetone as blank and the color value was expressed as ASTA units (ASTA 1997). Oleoresin content of the sample was estimated by following the procedure outlined by ASTA (1997), for which, the dry powdered sample was taken in a column and acetone was allowed to percolate overnight. The slurry was drained into a pre-weighed beaker and the solvent was evaporated to dryness. The viscous mass in the beaker is oleoresin. Percentage of oleoresin was computed based on the initial sample. Pungency was estimated by using High Performance Liquid Chromatography (HPLC) by slightly modifying the procedure of Collins *et al*. (1995). For sample preparation, 25 g of chilli powder was reflexed with 200 mL of ethyl alcohol for 5 h and 3-4 mL of the extract was filtered through 0.45 µM membrane using syringe filter into glass vials and analyzed using HPLC with mobile phase of 40% acetonitrile (40 mL) + 1% acetic acid (60 mL) followed by degassing. Capsaicin content was estimated on a Shimadzu HPLC system with SPD 10Avp detector and LC-6A HPLC pump. Mobile phase flow rate was 1.5 mL min^{-1} with reverse phase ODS Column C - 18. 250 × 4.6 mm. Injection volume was 25 µL of prepared chilli extract in alcohol with capsaicin 1 mg mL^{-1} alcohol as standard. The pungency was expressed as per cent capsaicin. The data thus collected were subjected to standard statistical analysis as per Gomez & Gomez (1986) and Townend (2002).

Results and discussion

The results showed significant differences in yield and quality traits (Tables 1 & 2) indicating presence of variability in the genotypes (Anu *et al*. 2002; Kumar *et al.* 2012; Prasath *et al.* 2007). Such variations indicated the scope for improving the population for these characters as suggested by Cherian (2000).

Weight of pericarp per fruit

Quantitative characters were significantly influenced by the genotypes (Tables 1 & 2). Among the indigenous germplasm, weight of pericarp (wet basis) was found to vary from 3.74 to 12.67 g per fruit. Kt-Pl-19 registered the highest pericarp weight per fruit, followed by Kt-Pl-19 variant -I, which were at par. The other genotypes namely, ICBD-10, ICBD-8, ICBD-3 and ICBD-19 recorded higher pericarp weight but were on par with each other. However, minimum pericarp weight was observed with CC-3 (3.74 g fruit^{-1}). Among the exotic collections, the weight of pericarp per fruit ranged from 3.10 g to 39.21 g, the highest being with SSP-1999 and the lowest being with IMI-5. Higher pericarp weight was recorded with PBC-171, EC-14 and Paprika King. High pericarp weight is an important quantitative character contributing towards yield of paprika powder, as it accounts for about 70% of the fruit weight (Gaddagimath 2000; Shiva *et al.* 2006). Varietal variation for pericarp weight was also reported by Anu *et al*. (2002) and Gaddagimath (2000) in paprika and paprika like chillies.

Yield per plant

Yield varied significantly among the genotypes, which ranged from 302 g plant^{-1} (CC-3) to 970 g (Kt-Pl-19) plant^{-1} with a mean value of 619 g. Among the indigenous germplasm, ICBD-8, ICBD-10, Kt-Pl-19 variant-1 produced higher yield than the others (Table 1). In the exotic paprika, the yield was in the range of 206–999 g plant^{-1}. The highest yield was noticed with EC-18, followed by SSP-1999, EC-35, PBC-171 and IMI-5, the minimum being with EC-171 (Table 2). The yield being a complex character is dependent on a number of component characters such as weight of pericarp as evident from Tables 1 & 2, which was also supported by Kumari *et al*. (2011) in paprika and by Gaddagimath (2000) in paprika and paprika like chillies. Variability for yield due to genotypes was also reported by Anu *et al*. (2002).

Total extractable color

The genotypes showed wide variation for the extractable color content ranging from 124 to 360 American Spice Trade Association (ASTA) units in indigenous germplasm and from 79 to 357 ASTA units in the exotic lines (Tables 1 & 2). Among the indigenous accessions, maximum color value was measured with ICBD-6, followed by ICBD-7, ICBD-11, ICBD-10 and ICBD-19 (Arka Abhir), while the minimum values were observed with CC-3. Kt-Pl-19, registered a color value of 218 ASTA units at Kozhikode, Kerala against a color value of

Table 1. Quality parameters of indigenous collections of paprika alike chillies

Accession/ Genotype	Source	Weight of pericarp fruit^{-1}(g)	Yield (g plant^{-1})	Capsaicin (%)	Color (ASTA units)
ICBD-1	Noolvi Dabbi (ND), Dharwad District, North Karnataka	7.89	583.8	0.098	276
ICBD-2	Annekeri Delux (AD), Dharwad District, North Karnataka	6.82	531.92	0.754	208
ICBD-3	Anthur Dabbi (Dabbi deluxe), Dharwad District, North Karnataka	8.75	681.03	0.324	282
ICBD-4 (B/9-1)	Benthur Dabbi (Dabbi typical), Dharwad District, North Karnataka	6.66	529.48	0.870	274
ICBD-5 (B/9-3)	Benthur Dabbi (Dabbi typical), Dharwad District, North Karnataka	6.92	516.60	0.863	220
ICBD-6 (B/9-5)	Benthur Dabbi (Dabbi typical), Dharwad District, North Karnataka	7.00	791.70	1.230	360
ICBD-7 (B/9-7)	Benthur Dabbi (Dabbi typical), Dharwad District, North Karnataka	6.41	680.00	0.517	343
ICBD-8 (B/K-1)	Benthur Dabbi (Dabbi typical), Dharwad District, North Karnataka	9.20	950.95	0.046	234
ICBD-9 (B/K-4)	Benthur Dabbi (Dabbi typical) (Khubihal village), Dharwad District, North Karnataka	6.81	728.64	0.986	206
ICBD-10 (B/4-1)	Benthur Dabbi (Dabbi typical), Dharwad District, North Karnataka	9.30	879.84	0.179	325
ICBD-11 (B/K-11)	Benthur Dabbi (Dabbi typical) (Khubihal village), Dharwad District, North Karnataka	5.36	504.81	0.312	335
ICBD-12 (B/K-14)	Benthur Dabbi (Dabbi typical) (Khubihal village), Dharwad District, North Karnataka	6.24	713.40	1.260	132
ICBD-13 (B/K-16)	Benthur Dabbi (Dabbi typical) (Khubihal village), Dharwad District, North Karnataka	4.75	443.25	0.744	202
ICBD-14 (B/9-11)	Benthur Dabbi (Dabbi typical) (Khubihal village), Dharwad District, North Karnataka	6.88	545.16	0.295	212
ICBD-15 (B/7-5)	Benthur Dabbi (Dabbi typical) (Khubihal village), Dharwad District, North Karnataka	6.35	763.53	0.472	162
ICBD-16 (B/y-13)	Benthur Dabbi (Dabbi typical) (Yeliwal village), Dharwad District, North Karnataka	6.58	703.48	0.982	234
ICBD-17 (B/y-2)	Benthur Dabbi (Dabbi typical) (Yeliwal village), Dharwad District, North Karnataka	6.14	554.76	1.042	231
ICBD-18 (B/y-4)	Benthur Dabbi (Dabbi typical) (Yeliwal village), Dharwad District, North Karnataka	5.36	391.50	0.603	224

Accession/ Genotype	Source	Weight of pericarp fruit^{-1}(g)	Yield (g plant^{-1})	Capsaicin (%)	Color (ASTA units)
ICBD-19 (Arka Abhir)	Indian Institute Horticultural Research, Bengaluru, Karnataka	8.46	747.96	0.358	316
Kt-Pl-19	Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh	12.67	970.14	0.341	218
Kt-Pl-19 variant-1	Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh	10.88	877.80	0.762	285
CC -1	Coorg collection, Karnataka	7.45	493.92	0.032	248
CC -2	Coorg collection, Karnataka	4.51	324.80	0.490	298
CC -3	Coorg collection, Karnataka	3.74	302.46	0.652	124
CC-4	Coorg collection, Karnataka	4.14	420.52	0.388	187
CC-5	Calicut collection, Kerala	4.25	454.56	0.823	173
SEm±		0.185	17.68	0.04	0.60
'F' test		**	**	**	**
CD (P < 0.05)		2.978	0.612	0.115	19.60
CV (%)		5.32	7.28	15.25	0.46

233.70 ASTA units recorded at Katrain, Himachal Pradesh (Joshi *et al.* 1997). EC-171 produced maximum color value, followed by EC-6 and EC-71, which significantly differed from each other among the exotic genotypes. The minimum color value of 79 ASTA units was observed with SSP-1999. The red color of paprika is imparted by a group of compounds known as ketocarotenoids, of which capsanthin and capsorubin together contribute 65%-80% of total color (Govindarajan 1986). Variation observed in the color value of the genotypes might be due to the varying proportions of these carotenoids. Moreover, the accumulation and retention of red pigments are cultivar dependent. These findings are in agreement with the results of Anu *et al.* (2002), Gaddagimath (2000) and Leela *et al*. (2004). Grouping of genotypes based on color value revealed that 16 genotypes (10 indigenous and 6 exotic) fell under group-I with color value of more than 250 ASTA units and 19 genotypes under group-II had color value between 201 to 250 ASTA units and six genotypes had between 161 and 200 ASTA units under group-III (Table 3). Generally, in trade the lower limit allowable for chilli powder is 120 ASTA units and for non-pungent paprika, it is 160-180 ASTA units (Hari *et al.* 2005). Accordingly, 40 genotypes (23 indigenous and 17 exotic) out of 44 having more than 160 ASTA units qualified for paprika type under high color group.

Pungency

Capsaicin, the pungent principle of chilli was found to vary from 0.032- 0.162%. The lowest capsaicin content was obtained with CC-1, followed by ICBD-8, ICBD-1, ICBD-10 and ICBD-14, while the highest with ICBD-12, among the indigenous germplasm. In the exotic lines, the capsaicin content ranged from 0.0056–0.54%, the lowest being with EC-490 and the highest being with EC-6. The genotypes, EC-45, EC-14 and EC-65 registered lesser capsaicin content (Tables 1 & 2). The variation observed in the capsaicin content of genotypes could probably be due to the presence of gene modifying factors for pungency and the ratio of placental tissue to seed and pericarp (Sreelathakumari 2000) and varietal variation as reported by Anu *et al.* (2002) in paprika and paprika like chillies and by Manju &

Table 2. Quality parameters of exotic collections of paprika

Accession/ Genotype	Source	Weight of pericarp fruit^{-1}(g)	Yield (g plant^{-1})	Capsaicin (%)	Color (ASTA units)
EC-45	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	7.44	604.80	0.010	233.20
EC-71	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	8.38	401.60	0.29	283.35
EC-43	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	6.14	351.96	0.38	227.15
EC-18	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	8.17	999.18	0.47	251.75
EC-490	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	7.07	454.72	0.0056	266.25
EC-35	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	6.16	899.00	0.36	231.70
EC-38	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	9.77	444.40	0.28	171.30
EC-31	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	7.16	337.07	0.43	204.85
EC-65	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	9.62	424.80	0.101	201.65
EC-20	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	8.65	329.7	0.39	251.1
EC-14	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	12.39	682.50	0.097	232.25
EC-171	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	3.37	206.23	0.32	356.65
EC-6	Asian Vegetable Research & Development Centre, Taiwan through NBPGR	5.95	278.54	0.54	304.35
PBC-171	Asian Vegetable Research & Development Centre, Taiwan	15.11	699.67	0.45	184.50
IMI-5	Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh	3.10	698.05	0.35	241.50
SSP-1999	Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh	39.21	966.96	0.27	79.00
Cayanne	Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh	7.31	273.00	0.39	191.00
Paprika King	Beltzville, USA through Synthite Chemicals, Kollencherry, Kochi, Kerala	11.11	675.15	0.30	247.00
SEm±		0.278	18.12	0.06	8.25
'F' test		**	**	**	**
CD ($P < 0.05$)		3.73	0.972	0.156	20.01
CV (%)		6.78	10.24	21.32	10.27

Table 3. Grouping of paprika alike chillies and paprika genotypes based on color value

Group & Color value (ASTA units)	Number	Genotypes	
		Paprika alike chillies	Paprika
I -Very High (>250)	16 (10 + 6)	ICBD-1, ICBD-3, ICBD-4, ICBD-6, ICBD-7, ICBD-10, ICBD-11, ICBD-19, Kt-Pl-19 variant –I, CC-2	EC-71, EC-18, EC-490, EC-20, EC-171, EC-6
II -High (201 – 250)	19 (11 + 8)	ICBD-2, ICBD-5, ICBD-8, ICBD-9, ICBD-13, ICBD-14, ICBD-16, ICBD-17, ICBD-18, Kt-Pl-19, CC-1	EC-45, EC-43, EC-35, EC-31, EC-65, EC-14, IMI-5, Paprika King
III -Medium (161 – 200)	6 (3 + 3)	ICBD-15, CC-4, CC-5	EC-38, PBC-171, Cayenne
IV -Low (100 – 160)	2 (2 + 0)	ICBD-12, CC-3	-
V -(Very Low) (<100)	1 (0 + 1)	-	SSP-1999

Table 4. Grouping of paprika alike chillies and paprika genotypes based on pungency

Group & Capsaicin content (%)	Number	Genotypes	
		Paprika alike chillies	Paprika
I -Chilli paprika (>0.5)	15 (14 + 1)	ICBD-2, ICBD-4, ICBD-5, ICBD-6, ICBD-7, ICBD-9, ICBD-12, ICBD-13, ICBD-16, ICBD-17, ICBD-18, Kt-Pl-19 variant –I, CC-3, CC-5	EC-6
II -Good paprika (0.1 – 0.5)	22 (9 + 13)	ICBD-3, ICBD-10, ICBD-11, ICBD-14, ICBD-15, ICBD-19, Kt-Pl-19, CC-2, CC-4	EC-18, EC-20, EC-38, EC-171, EC-6, EC-43, EC-35, EC-31, EC-71, IMI-5, Paprika King, PBC-171, Cayenne
III -Best paprika (<0.1)	7 (3 + 4)	ICBD-1, ICBD-8, CC-1	EC-45, EC-490, EC-65, EC-14

Sreelathakumary (2002b) and by Kumar *et al*. (2012) in chillies. Both the exotic and indigenous germplasm were placed under three groups having capsaicin content below 0.1%, between 0.1% to 0.5% and more than 0.5% (Table 4), as suggested by Govindarajan (1985). Based on the pungency, seven genotypes fell under group-III (best paprika), while 22 genotypes under group-II (good paprika) and the remaining genotypes under group-I (chilli paprika).

Oleoresin content

Oleoresin varied from 11.28-22.23%, the highest being with ICBD-11, followed by ICBD-15, ICBD-19 (Arka Abhir) and ICBD-10 and the lowest being with CC-3 in the indigenous germplasm of paprika like chillies (Fig.1). Such kind of variation for oleoresin content due to genotypes was also obtained by Manju & Sreelathakumary (2002b) in hot chillies. Ten genotypes having high oleoresin content (>16%) were placed under group-I, which can be used as breeding material for crop improvement programme, followed by 16 genotypes under group-II with medium oleoresin content (10-16%) (Table 5).

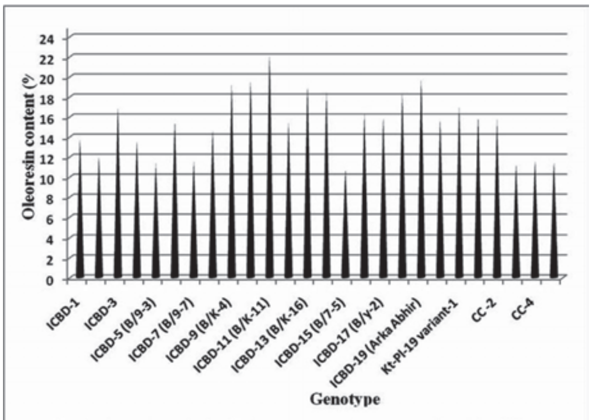

Fig. 1. Oleoresin content of indigenous germplasm of paprika alike chillies

variability both in the indigenous and exotic germplasm possessing desirable quality characteristics i.e., color value > 250 ASTA units, oleoresin > 16% and pungency < 0.1%. Based on yield and quality parameters, the genotypes ICBD-10, ICBD-8 and EC-18 were found suitable for paprika industry with high yield (> 850 g plant^{-1}) and high quality attributing characters (> 200 ASTA units and < 0.5% capsaicin). The breeders can make use of these promising lines for the production of varieties with outstanding quality attributes.

Table 5. Grouping of paprika alike chilly genotypes based on oleoresin content

Group & Oleoresin content (%)	Number	Genotypes
I -High (>16)	10	ICBD-3, ICBD-9, ICBD-10, ICBD-11, ICBD-13, ICBD-14, ICBD-18, ICBD-19, Kt-Pl-19 variant –I, CC-1
II -Medium (10 – 16)	16	ICBD-1, ICBD-2, ICBD-4, ICBD-5, ICBD-6, ICBD-7, ICBD-8, ICBD-12, ICBD-15, ICBD-16, ICBD-17, Kt-Pl-19, CC-2, CC-3, CC-4, CC-5
III -Low (< 10)	-	-

Coefficient of variation (CV)

Wide to narrow variability was observed for all the traits studied (Tables 1 & 2). Among the traits, maximum coefficient of variation was obtained for capsaicin content (15.25%), followed by yield plant^{-1} (7.28%) and weight of pericarp fruit^{-1} (5.32%), while minimum variation was estimated for color value in the indigenous germplasm. Similarly maximum variation was recorded for capsaicin content, followed by color and yield plant^{-1} and minimum variation for weight of pericarp in the exotic collections. Wide variation suggested the presence of high genetic variability, while narrow or minimal variation indicated the desirability of selection. Likewise, variations for various traits in paprika and paprika alike chillies were reported by Anu *et al*. (2002), Kumar *et al*. (2012) and Manju & Sreelathakumary (2002a & b).

The present study indicated the presence of

Acknowledgments

The authors are thankful to the Director, Indian Institute of Spices Research, Kozhikode, Kerala for providing the necessary facilities.

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