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Quantification and correlation of anthocyanin pigments and their antioxidant activities in rose (*Rosa hybrida*) varieties

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ABSTRACT

The present study was conducted to evaluate the total anthocyanin content and their antioxidant activities in 50 Indian rose (*Rosa hybrid* L.) varieties. Total anthocyanin content among varieties was found maximum in December as compared to March. The total anthocyanin content differed significantly among all the varieties. The varieties with dark colours were richest in anthocyanin content than the light coloured varieties. A similar trend was also observed for antioxidant activity. The variety Ashwini, a dark red colour rose recorded highest anthocyanin content (578.10 mg/100g) followed by Dr S S Bhatnagar (369.86 mg/100g) and Nehru Centenary (288.15 mg/100g); whereas minimum anthocyanin content was recorded in white coloured varieties, i.e. Iceberg (0.24 mg/100g) followed by Mridula (0.53 mg/100g) and Shabnam (1.38 mg/100g). Among all the varieties tested, Ashwini recorded maximum antioxidant activity (512.71 µmol Trolox/g), whereas least antioxidant activity was found in Iceberg (13.93 µmol Trolox/g). The antioxidant capacity of all the varieties is correlated positively (R= 0.945) with their total anthocyanin content. This investigation will help to explore the possibilities of utilizing anthocyanin pigments from rose as potential nutraceutical, natural food colourant and also in breeding programmes for developing varieties with higher anthocyanin content. The findings also suggest that the dark colour can serve as an indicator of antioxidant activity.

Key words: Antioxidants, Anthocyanin, CUPRAC, Food colourant, Nutraceutical, Rose

Rosa hybrid L., of the family Rosaceae, is one of the most important commercial flower crops with over 150 species and more than 20 000 cultivars (Cai *et al*. 2005) with colour spectre ranging from subtle whites, yellows and pinks to intense purple, orange and red tones. Its flower colour is attributed to the presence of anthocyanins and carotenoids (Eugster *et al*. 1991). Rose petals have been consumed as a food ingredient in teas, cakes, and flavour extracts as well as medicinal remedies of various illnesses (Lin *et al*. 2014). The rose flower is known as an astringent, stomachic, and is used traditionally as an agent for activating blood circulation to relieve blood stasis, and counteracting toxin. Being rich in anthocyanin content, rose petals are a good colourant and potentially a good source of antioxidants.

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Anthocyanins, belong to flavonoid family, are responsible for the brilliant colours of numerous fruits, flowers and vegetables. Their specific colour depends on co-pigments, metal ions and pH (Tanaka *et al*. 2008). In the structure of anthocyanins, 17 anthocyanidins have been distinguished, the most common of which are cyanidin, delphinidin, pelargonidin, peonidin, malvidin and petunidin (Mlodzinska 2009). Anthocyanins not only endow nature with attractive colours but also give plants a variety of physiological health and disease prevention effects. They attract the pollinators and help in reproduction. Previous studies have revealed that anthocyanin compounds have a high free radical scavenging capacity and play an essential role in the prevention of cardiovascular disease, obesity, cancer, diabetes and other diseases (Prior and Wu 2006). The high radical scavenging ability of anthocyanin is mainly due to the phenolic hydroxyl groups in molecule (Qin and Xiaojun 2013). Anthocyanins were found to have many times more activity than common antioxidants such as ascorbate (Wang *et al*. 1997). Overall, there is now increasing evidence that antioxidants in the human diet are of major benefit for health and well-being.

The adverse effects of oxidative stress on human health have become a serious issue. Under such condition, human body produces more reactive oxygen species (ROS) than

antioxidants, this imbalance leads to damage of biological structures such as proteins, lipids and DNA and induce a variety of human diseases such as cancer, cardiovascular, rheumatoid arthritis, cataract and others (Kourie 1998). Therefore, dietary antioxidants should be consumed. Antioxidants are widely used as a food additive to provide protection against oxidative degradation of foods by free radicals. Antioxidants products can be synthetic or natural. The use of synthetic antioxidants is restricted because of their toxicity, including carcinogenicity (Ashwini and Krishnamoorthy 2011). According to Siger *et al*. (2012), the interest in natural antioxidants has increased considerably in recent years due to their beneficial effects in preventing and reducing the risk of various diseases.

However, very limited research work has been done to evaluate anthocyanin content and antioxidant activity of roses. Hence, this study was undertaken to investigate the total anthocyanin content and antioxidant activity of rose varieties.

MATERIALS AND METHODS

In the present study, 50 rose varieties were used for estimation of total anthocyanin content and their antioxidant activity. Fresh rose petals were collected from the Research Farm of the Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi during two different growing seasons, i.e. December 2014 and March 2015. The planting material used in the present study included 49 Indian varieties namely Pusa Arun, Raktima, Nehru Centenary, Pusa Bahadur, Lalima, Bhim, Ashwini, Dr. S.S. Bhatnagar, Jantar Mantar, Jawani, Raktagandha, Pusa Mohit, Pusa Ajay, Pusa Muskan, Pusa Barahmasi, Pusa Virangana, Pusa Priya, Dr. Bharat Ram, Dr. M. S. Randhawa, Priyadarshini, Dulhan, Dr. B.P. Pal, Anurag, Arjun, Haseena, Raja Surendra Singh of Nalagarh, Sadabahar, Nurjehan, Pink Montezuma, Surekha, Dr. Benjamin Pal, Pusa Ranjana, Arunima, Manasi, Rose Sherbet, Pusa Garima, Pusa Gaurav, Suryakiran, Krishna, Shola, Pusa Pitamber, Lahar, Ganga, Raja Ram Mohan Roy, Pusa Abhishek , Mridula, Shabnam, Chingari, Surkhab and one exotic variety namely, Iceberg.

The anthocyanins were extracted according to the methodology of Wrolstad *et al*. (2005). Petals (0.5 g) of fifty varieties were extracted with acidified methanol (methanol + 1% HCl) in ultra sonicator water bath for 30 min. The extracts were centrifuged at 10,000 rpm for 10 min by using refrigerated centrifuge. Final volume was prepared by adding the acidified methanol (methanol + 1% HCl) to the supernatant. Then final samples were prepared by taking the 5 ml volume of sample and dilutes separately in potassium chloride buffer 0.025 M (pH 1.0) and sodium acetate buffer 0.4 M (pH 4.5) (5ml each). After 15 min of incubation at room temperature, absorption was measured at 520 and 700 nm. Absorbance readings were made at room temperature against distilled water as blank. A Jasco V 530 UV-Vis spectrophotometer was used for measurements. Absorbance was calculated as $A = [(A_{510} - A_{700})$ at pH 1.0] − [$(A_{510} - A_{700})$ at pH 4.5] with a molar extinction coefficient of 26,900 for anthocyanin. The total anthocyanin content was calculated as cyanidin-3-glucoside equivalents as:

Anthocyanin content (mg/g) = $(A \times MW \times DF \times V \times 10^3) / (\varepsilon \times L \times m)$

where, A is absorbance, MW is the molecular weight of cyanidin-3-glucoside (449.2 Da), DF is the dilution factor, V is the final volume (ml), 10^3 is the factor for conversion from g to mg, ε is the cyanindin-3-glucoside molar absorbance (26900), L is the cell path length (1 cm), and m is the petal weight (g).

Each 0.5 g sample was extracted with 20 ml 80% ethanol. The extract was then centrifuged at 10,000 rpm at 4°C for 20 min. The supernatant was taken for determinations including total antioxidant activity by CUPRAC.

Antioxidant activity was determined by *Cupric reducing antioxidant capacity (CUPRAC)* assay, which was standardized by Apak *et al*. (2004). To a test tube, 1ml each of copper (II) chloride solution (10^{-2} M), Neocuproine solution (Nc) (7.5×10^{-3} M), and ammonium acetate (NH_4Ac) buffer (pH 7) solutions were added. Antioxidant sample solution (0.1 ml) and H_2O (1.0 ml) were added to the initial mixture so as to make the final volume 4.1 ml and mixed well. Absorbance against a reagent blank was measured at 450 nm after 30 min. Trolox was used as standard and total antioxidant capacity of extracts was expressed as µmol Trolox/g.

$$\text{Antioxidant capacity (µmol Trolox/g)} = (A/\varepsilon_{TR})\,(V_f/V_s)\,r\,(V_t/m)$$

where, A is absorbance, ε_{TR} is Molar absorptivity of Trolox (1.67×10^4), V_f is final volume made (4.1 ml), V_s is sample volume taken from diluted extract (ml), V_t is total volume (ml), R is dilution factor, m is weight of sample taken (g).

Results are expressed as mean ± standard deviation and are representative of three independent experiments. Statistical analysis was performed using software SAS-GLM V 9. A value of $P<0.05$ was considered significant.

RESULTS AND DISCUSSION

Total anthocyanin content

The total anthocyanin content of rose varieties in two consecutive growing seasons (December 2014 and March 2015) is presented in Table 1. Data showed a significant variation for anthocyanin content of all the varieties in both the seasons. Higher anthocyanin content was observed for all the varieties in December 2014 as compared to March 2015. These results suggest that the anthocyanin contents of rose petals is strongly influenced by environmental factors (temperature and light) and action of osmotic adjusters during periods of drought and low temperatures (Stintzing and Carle 2004). Howard *et al*. (2003) evaluated the total anthocyanin content of blueberry in two growing seasons and they found that total anthocyanin content was affected more by differences in environmental growth conditions. Temperature is one of the major environmental factors that affect anthocyanin accumulation; anthocyanin content is reduced under high temperatures in petunia (Shvarts *et al*.

Table 1 Effect of seasons on total anthocyanin content of rose varieties

Variety	Colour	Anthocyanin content in December 2014 (mg/100g)	Anthocyanin content in March 2015 (mg/100g)	Mean of both seasons (mg/100g)
Pusa Arun	Dark red	317.17±1.69	248.03±8.60	282.60±4.75
Raktima	Red	210.67±4.55	194.59±3.73	202.63±1.31
Nehru Centenary	Dark red	300.82±1.59	275.47±4.03	288.15±2.22
Pusa Bahadur	Red	134.40±2.67	115.34±2.25	124.87±1.13
Lalima	Red	116.85±1.48	107.33±1.35	112.09±0.92
Bhim	Red	246.96±1.56	225.43±2.59	236.20±0.69
Ashwini	Dark red	667.46±21.27	488.73±3.09	578.10±11.71
Dr S S Bhatnagar	Dark red	401.24±1.59	338.48±2.06	369.86±0.26
Jantar Mantar	Red	123.43±1.48	116.70±1.73	120.07±1.52
Jawani	Red	75.44±0.88	67.30±2.85	71.37±0.99
Raktaghandha	Red	188.78±0.97	176.37±1.51	182.58±1.22
Pusa Mohit	Pink	87.85±1.83	61.81±0.77	74.83±0.86
Pusa Ajay	Pink	40.23±0.38	35.13±2.39	37.68±1.38
Pusa Muskan	Colour blend (Cream with pink edges)	47.94±1.11	20.48±0.89	34.21±0.91
Pusa Barahmasi	Pink	110.96±2.26	64.89±3.22	87.92±2.20
Pusa Virangana	Red	235.22±7.63	125.78±1.71	180.50±4.49
Pusa Priya	Pink	12.25±1.340	9.26±0.32	10.76±0.81
Dr Bharat Ram	Pink	7.450±0.80	5.27±1.06	6.36±0.82
Dr M S Randhawa	Colour blend (White and pink)	14.87±0.97	13.43±0.83	14.15±0.11
Priyadarshini	Colour blend (White and pink)	14.58±1.79	9.96±0.92	12.27±1.20
Dulhan	Red	76.80±1.40	64.56±1.99	70.68±1.51
Dr B P Pal	Pink	66.82±1.08	61.40±0.64	64.11±0.68
Anurag	Pink	27.48±1.25	19.49±0.83	23.49±0.28
Arjun	Pink	56.83±2.29	48.89±0.37	52.86±1.25
Haseena	Pink	82.57±1.75	74.74±2.51	78.66±0.43
Raja Surendra Singh of Nalagarh	Pink	44.76±1.08	40.51±0.61	42.63±0.85
Sadabahar	Pink	30.84±1.25	25.82±0.73	28.33±0.57
Nurjehan	Pink	29.21±1.59	26.24±0.53	27.73±0.61
Pink Montezuma	Pink	11.99±0.95	9.23±0.88	10.61±0.92
Surekha	Pink	21.01±2.17	18.26±1.03	19.64±1.09
Dr Benzamin Pal	Pink	14.15±1.11	11.83±0.53	12.99±0.72
Pusa Ranjana	Deep pink	109.33±2.29	99.65±1.06	104.49±1.60
Arunima	Pink	28.20±1.56	22.83±1.81	25.52±0.57
Mansi	Pinkish white	3.88±0.28	2.73±0.13	3.31±0.13
Rose Sherbet	Deep pink	143.68±1.94	100.29±0.56	121.98±1.17
Pusa Garima	Pink	50.66±2.24	41.97±1.69	46.32±1.94
Pusa Gaurav	Deep pink	102.99±3.30	92.23±1.89	97.61±2.42
Suryakiran	Orange	108.38±1.24	85.00±0.84	96.69±0.84
Krishna	Orange	32.29±0.51	28.28±1.20	30.29±0.37
Shola	Orange	55.94±1.19	51.59±1.95	53.76±0.95
Pusa Pitamber	Yellow	4.24±0.28	3.66±0.41	3.95±0.16
Lahar	Yellow	5.13±0.70	3.95±0.97	4.54±0.67
Ganga	Pale yellow	2.14±0.12	1.69±0.27	1.92±0.17

Cond.

Table 1 (*Concluded*)

Variety	Colour	Anthocyanin content in December 2014 (mg/100g)	Anthocyanin content in March 2015 (mg/100g)	Mean of both seasons (mg/100g)
Raja Ram Mohan Roy	Yellow	4.33±0.55	3.29±0.35	3.81±0.44
Iceberg	White	0.27±0.03	0.21±0.04	0.24±0.04
Mridula	White	0.64±0.07	0.42±0.06	0.53±0.06
Shabnam	White	1.62±0.17	1.13±0.29	1.38±0.23
Chingari	Bicolored (Yellow + red)	55.10±0.22	28.83±0.99	41.97±0.54
Surkhab	Bicolored (red + white)	85.14±1.58	79.19±2.36	82.17±1.72
Pusa Abhishek	Striped (Pink with white stripes)	66.29±1.30	62.10±1.91	64.20±1.48
SE(d)		2.90	1.68	1.77
CD (P=0.05)		5.76	3.33	3.52
CV		3.80	2.70	2.56

1997), rose (Dela *et al*. 2003), chrysanthemum (Nozaki *et al*. 2006) and grape (Mori *et al*. 2005). These results were also in confirmation with the findings of Ginova *et al*. (2013) who reported that anthocyanin content varies in response to environmental conditions such as growth temperature and light intensity. Anthocyanin concentration increases under low temperatures in the flowers of *Plantago lanceolata* (Stiles *et al*. 2007).

The results presented in Table 1 indicated that there was a significant variation among the rose varieties for the total anthocyanins. The total anthocyanin content ranged from 0.24 to 578.10 mg/100g on fresh weight basis. Lin *et al*. (2014) reported that total content of anthocyanin rose petals varied from 0.025 to 18.69 mg/g. In the present study, rose variety Ashwini, a dark red colour variety recorded highest anthocyanin content (578.10 mg/100g) followed by Dr S S Bhatnagar (369.86 mg/100g) and Nehru Centenary (288.15 mg/100g). The minimum anthocyanin content was recorded in white colour varieties, i.e. Iceberg, Mridula and Shabnam (0.24 mg/100g, 0.53 mg/100g and 1.38 mg/100g). High anthocyanin content was observed in dark red flowers followed by deep pink, orange, pink, yellow and white (Table 1). The level of anthocyanin content was differed significantly between dark red and other colours of the flowers. Similar results were reported by Park *et al*. (2015) and Shisa Ullas *et al.* (2017). They found that the red and purple coloured chrysanthemum varieties showed high amounts of anthocyanins in their petals compared to other colours. Our study was also supported by Lee *et al*. (2011) who reported anthocyanin content of 375 mg/100g in red petals of Korean edible rose (*Rosa hybrida* cv. Noblered). Qin and Xiaojun (2013) reported the anthocyanin content in petals of Yunnan edible rose was (353.56 ± 2.50) mg Cy-3,5-diglu per 100 g FW. Gonzalez *et al*. (2012) reported the anthocyanin content in hibiscus as 209 mg/100g of fresh weight.

Antioxidant activity

Antioxidants are capable of deactivating free radical before the latter attack cells and biological targets (Atoui *et al*. 2005). Therefore, their activity will be critical for maintaining optimal protection. In the present study, antioxidant activity of rose petals was tested using cupric reducing antioxidant capacity (CUPRAC) method, which is an easy, rapid and sensitive way to estimate the antioxidant activity of a specific compound or plant extracts (Apak *et al*. 2004). Higher antioxidant activity was observed for all the varieties in December 2014 as compared to March 2015. Ginova *et al*. (2013) also reported seasonal effect on antioxidant activity of rose petals. Antioxidant activity of different rose varieties varied widely from each other. The CUPRAC values of rose varieties ranged from 13.93 µM Trolox/g for Iceberg to 512.71 µM Trolox/g for Ashwini. Dark red coloured varieties recorded highest antioxidant activity compared to pink, orange, yellow and white coloured varieties (Table 2). Similar results were reported by Sadighara *et al*. (2012); they studied antioxidant activity of *Althaea officinalis* by CUPRAC method and found that reddish pink flowers of *Althaea officinalis* had more antioxidant activity than pink and white flowers. The level of antioxidant activity was significantly different between red and other colours of the flowers. Data from Table 1 and Table 2 showed that the flower colour plays a role not only on the content of anthocyanins, but also on the antioxidant power. Specifically, red colour is generally associated to high values of the antioxidant power and white colour to the lowest ones. The possible reason for this variation in antioxidant content of rose varieties may be due to genotypic effect. Suzan and Sezai (2011) concluded that antioxidant activity was influenced by genotype in *Rosa* taxa. Red flowered cultivars reported higher antioxidant activity as compared to others. The results of present investigation were in agreement with the findings of Benvenuti *et al*. (2016) and Sadighara *et al*. (2012). Soare *et al*. (2015) reported that antioxidant activity of *Rosa canina* varied from 99.3 to 363.44 µmol TE/g fresh weight.

Correlation between anthocyanin content and antioxidant activity

In the present study, the results suggest that the strong positive correlation (r = 0.945) was found between

Table 2 Effect of seasons on antioxidant activity of rose varieties

Variety	Colour	Antioxidant activity in December 2014 (µmol Trolox/g)	Antioxidant activity in March 2015 (µmol Trolox/g)	Mean (µmol Trolox/g)
Pusa Arun	Dark red	408.18±1.78	351.72±1.96	379.95±0.73
Raktima	Red	298.78±1.57	234.49±4.49	266.65±2.75
Nehru Centenary	Dark red	448.01±2.01	369.52±1.01	408.77±1.38
Pusa Bahadur	Red	259.60±2.32	200.07±0.61	229.84±1.08
Lalima	Red	238.67±9.47	190.10±3.25	214.39±4.92
Bhim	Red	385.50±10.06	318.49±2.35	351.99±5.25
Ashwini	Dark red	550.05±2.88	475.37±4.64	512.71±3.48
Dr S S Bhatnagar	Dark red	471.68±6.28	393.84±3.17	432.76±3.40
Jantar Mantar	Red	241.853±24.55	189.34±1.60	215.59±11.76
Jawani	Red	180.423±1.96	108.93±1.58	144.68±1.71
Raktaghandha	Red	303.670±14.21	245.74±5.10	274.71±7.19
Pusa Mohit	Pink	193.167±3.11	107.37±2.21	150.27±0.58
Pusa Ajay	Pink	157.383±3.744	85.96±1.76	121.67±1.72
Pusa Muskan	Colour blend (Cream with pink edges)	100.96±1.08	55.29±0.50	78.12±0.79
Pusa Barahmasi	Pink	194.52±5.98	109.59±0.96	152.06±3.04
Pusa Virangana	Deep pink	270.80±1.89	198.23±1.52	234.52±1.53
Pusa Priya	Pink	79.95±0.87	50.17±0.46	65.06±0.58
Dr Bharat Ram	Pink	50.74±1.85	32.32±2.89	41.53±0.86
Dr M S Randhawa	Colour blend (White and pink)	95.40±1.29	62.95±2.63	79.17±0.94
Priyadarshini	Colour blend (White and pink)	86.97±0.97	54.72±1.27	70.85±0.79
Dulhan	Red	193.68±2.75	102.29±1.52	147.99±2.03
Dr B P Pal	Pink	198.44±2.20	109.52±3.57	153.98±1.15
Anurag	Pink	103.03±3.18	69.23±1.68	86.13±0.88
Arjun	Pink	199.98±0.95	110.23±2.04	155.10±1.49
Haseena	Pink	227.77±1.77	161.07±2.69	194.42±1.60
Raja Surendra Singh of Nalagarh	Pink	189.95±1.94	106.18±4.79	148.07±2.35
Sadabahar	Pink	138.92±1.17	89.52±1.12	114.22±0.38
Nurjehan	Pink	138.48±2.18	84.05±3.26	111.26±1.13
Pink Montezuma	Pink	96.09±0.96	55.52±0.94	75.80±0.89
Surekha	Pink	105.52±2.11	74.79±1.57	90.16±0.99
Dr Benzamin Pal	Pink	97.50±0.94	61.90±1.17	79.70±0.24
Pusa Ranjana	Deep pink	256.76±6.53	199.60±1.77	228.18±2.39
Arunima	Pink	123.19±2.54	77.62±1.75	100.40±0.82
Mansi	Pinkish white	38.38±1.32	23.37±1.03	30.88±0.43
Rose Sherbet	Deep pink	270.98±4.64	214.78±1.74	242.88±3.18
Pusa Garima	Pink	196.37±0.34	117.17±2.18	156.77±1.18
Pusa Gaurav	Deep pink	240.25±1.01	178.20±2.28	209.22±0.93
Suryakiran	Orange	236.77±3.52	171.92±1.59	204.34±1.52
Krishna	Orange	138.08±1.51	81.75±0.87	109.91±1.19
Shola	Orange	198.66±1.16	151.50±2.07	175.08±0.73
Pusa Pitamber	Yellow	42.21±1.60	29.67±1.00	35.94±0.73
Lahar	Yellow	47.51±1.35	32.54±0.59	40.02±0.43

Cond.

Table 2 (*Concluded*)

Variety	Colour	Antioxidant activity in December 2014 (µmol Trolox/g)	Antioxidant activity in March 2015 (µmol Trolox/g)	Mean (µmol Trolox/g)
Ganga	Pale yellow	29.58±0.71	19.77±0.94	24.68±0.25
Raja Ram Mohan Roy	Yellow	44.01±1.09	30.76±0.29	37.39±0.64
Iceberg	White	16.17±0.97	11.70±0.95	13.93±0.96
Mridula	White	19.20±1.52	13.51±0.64	16.36±0.86
Shabnam	White	27.77±0.82	16.50±0.46	22.14±0.23
Chingari	Bicolored (Yellow+ red)	148.02±1.38	99.44±0.99	123.73±0.50
Surkhab	Bicolored (red+white)	232.10±1.29	165.63±0.95	198.87±0.90
Pusa Abhishek	Striped (Pink with white stripes)	197.96±1.46	143.59±2.55	170.77±1.19
SE(d)		4.13	1.80	2.15
CD (P=0.05)		8.201	3.561	4.262
CV		2.75	1.656	1.660

antioxidant activity and total anthocyanin content of rose petals. The values of the CUPRAC radical scavenging activity showed positive correlation with those of total anthocyanin: the correlation coefficient, r^2, was 0.892 (Fig 1). From the Fig 1 it was clear that as anthocyanin content increases, antioxidant activity also increases. The result of present study was in agreement with the findings of Ozgen *et al.* (2010). They reported that the total anthocyanin content of *Sambucus canadensis* was highly correlated to antioxidant capacity values (r = 0.70-0.85). Adina *et al*. (2010) also reported that antioxidant activity of berries was directly proportional to the anthocyanin content.

Pigmented plants are outstanding sources for antioxidant compounds. Therefore, plants with deep colour are excellent choices for antioxidant activity. Anthocyanins are powerful antioxidants and contribute to the red, purple, and blue colours in plants. Therefore, there is a possible link between the anthocyanin level in the deep colour of plant and their antioxidant capacity. Collectively, the flowers with more pigmentation have more biological effects in association with antioxidant potentials, and this fact should be considered by food industries, nutraceutical industries and pharma industries in choosing antioxidant sources because these results showed dark coloured flowers possess more antioxidant activity. The varieties, viz. Ashwini, Dr S S Bhatnagar, Nehru centenary, Pusa Arun, Bhim and Raktima are most suitable for the extraction of anthocyanin pigments because they reported maximum total anthocyanin content. Higher anthocyanin content and high antioxidant activity was reported in December 2014 as compared to March 2015 in all the varieties. This variation was may be due low temperature anthocyanin accumulation. Therefore, it can be concluded that rose petals have to be collected in the month of December in order to obtain petals with higher levels of anthocyanin content and antioxidant activity for food and nutraceutical uses.

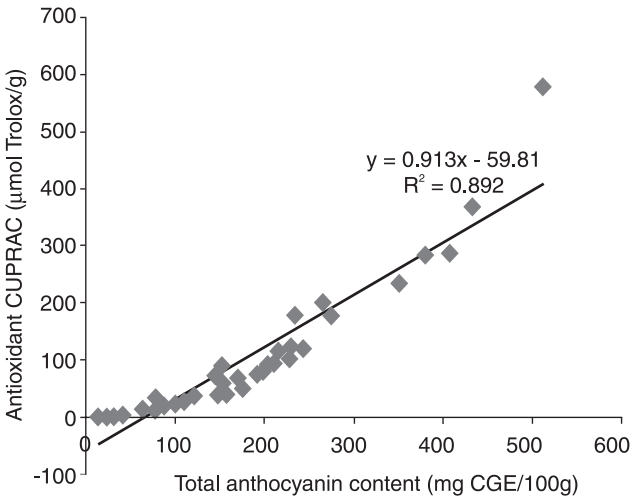

Fig 1 Correlation between total anthocyanin content and antioxidant activity of rose petals

REFERENCES

Adina C, Mariana N S, Cristian T and Raluca P. 2010. Comparative analysis of bilberries alcoholic extracts regarding to anthocyanins content, total phenolics and antioxidant activity. *Annals of Chemistry* **21**(1): 5–19.

Apak R, Guculu K, Ozyurek M and Karademir S E. 2004. Novel total antioxidant capacity index for dietary polyphenols and vitamins C and E, using their cupric ion reducing capability in the presence of neocuproine: CUPRAC method. *Journal of Agricultural and Food Chemistry* **52**: 7970–81.

Ashwini P and Krishnamoorthy M. 2011. Antioxidant activity of ethanolic extract of *Cassia tora*. *International Journal of Research in Ayurveda and Pharmacy* **2**: 250–2.

Atoui A K, Abdelhak M, Boskou G and Kefalas P. 2005. Tea and herbal infusions: their antioxidant activity and phenolic profile. *Food Chemistry* **89**: 27–36.

Benvenuti S, Bortolotti E and Maggini R. 2016. Antioxidant power, anthocyanin content and organoleptic performance of edible flowers. *Scientia Horticulturae* **199**: 170–7.

Cai Y Z, Xing J Sun M, Zhan Z Q and Corke H. 2005. Phenolic antioxidants (hydrolysable tanins, flavonols and anthocyanins) identifed by LC-ESI-MS and MALDI-QIT-TOF MS from *Rosa chinensis* flowers. *Journal of Agricultural and Food Chemistry* **53**: 940–8.

Dela G, Or E, Ovadia R, Nissim-Levi A, Weiss D and Oren-Shamir M. 2003. Changes in anthocyanin concentration and composition in 'Jaguar' rose flowers due to transient high-temperature conditions. *Plant Science* **164**: 333–40.

Eugster H, Chem D and Fischer M. 1991. The chemistry of rose pigments. *Angewandte Chemie* **30**: 654–72.

Ginova A, Mihalev K and Kondakova V. 2013. Antioxidant capacity of petals and leaves from different rose (*Rosa damascena* mill.) plantations in Bulgaria. *International Journal of Pure and Applied Bioscience* **1**(2): 38–43.

Gonzalez C S, Fidel T, Vergara B, Ana E, Ortega R and Jose. 2012. Antioxidant properties and color of *Hibiscus sabdariffa* extracts. *Ciencia e Investigacion Agraria* **39**(1): 79-90.

Howard L R, Clark J R and Brownmiller C. 2003. Antioxidant capacity and phenolic content in blueberries as affected by genotype and growing season. *Journal of the Science of Food and Agriculture* **83**(12): 1238–47.

Kourie J I. 1998. Interaction of reactive oxygen species with ion transport mechanism. *American Journal of Physiology* **275**: 1–24.

Lee J H, Lee H J and Choung M G. 2011. Anthocyanin compositions and biological activities from the red petals of Korean edible rose (*Rosa hybrida* cv. Noblered). *Food Chemistry* **129**: 272–8.

Lin L, Hyeonmi H, Jeehye S, Younghwa K and Heon-Sang J L. 2014. Antioxidant activities of methanolic extracts from four different rose cultivars. *Journal of Food and Nutrition Research* **2**(2): 69–73.

Mlodzinska E. 2009. Survey of plant pigments: molecular and environmental determinants of plant colours. *Acta Biologica Cracoviensia Series Botanica* **51**(1): 7–16.

Mori K, Sugaya S and Gemma H. 2005. Decreased anthocyanin biosynthesis in grape berries grown under elevated night temperature condition. *Scientia Horticulturae* **105**: 319–30.

Nozaki K, Takamura T and Fukai S. 2006. Effects of high temperature on flower colour and anthocyanin content in pink flower genotypes of greenhouse chrysanthemum (*Chrysanthemum morifolium* Ramat.). *Journal of Horticultural Science and Biotechnology* **81**: 728–34.

Ozgen M, Scheerens J C, Reese R N and Miller R A. 2010. Total phenolic, anthocyanin contents and antioxidant capacity of selected elderberry (*Sambucus canadensis* L.) accessions. *Pharmacognosy Magazine* **6**(23): 198–203.

Park C H, Chae S H, Park S Y, Kim J K, Kim Y J, Chung S O, Arasu M V, Al-Dhabi N A and Park S U. 2015. Anthocyanin and carotenoid contents in different cultivars of *chrysanthemum* (*Dendranthema grandiflorum* Ramat.) flower. *Molecules* **20**: 11090–102.

Prior R L and Wu X. 2006. Anthocyanins: Structural characteristics that result in unique metabolic patterns and biological activities. *Free Radical Research* **40**: 1014–28.

Qin G and Xiaojun M. 2013. Composition and antioxidant activity of anthocyanins isolated from Yunnan edible rose. *Food Science and Human Wellness* **2**: 68–74.

Sadighara P, Gharibi S, Jafari A M, Khaniki G J and Samira S. 2012. The antioxidant and flavonoids contents of *Althaea officinalis* L. flowers based on their colour. *Avicenna Journal of Phytomedicine* **2**(3): 113–7.

Shvarts M, Borochov A and Weiss D. 1997. Low temperature enhances petunia flower pigmentation and induces chalcone synthase gene expression. *Physiologia Plantarum* **99**: 67–72.

Siger A, Czubinski J, Kachlicki P, Dwiecki K, Lampart-Szczapa E and Nogala-Kalucka M. 2012. Antioxidant activity and phenolic content in three *Lupin* species. *Journal of Food Composition and Analysis* **25**: 190–7.

Soare R, Babeanu C, Bonea D and Pania O. 2015. The content of total phenols, flavonoids and antioxidant activity in rosehip from the spontaneous flora from South Romania. *Scientific Papers Series A Agronomy* **58**: 307–14.

Stiles E A, Cech N B, Dee S M and Lacey E P. 2007. Temperature sensitive anthocyanin production in flowers of *Plantago lanceolata*. *Physiologia Plantarum* **129**: 756–65.

Stintzing F C and Carle R. 2004. Functional properties of anthocyanins and betalains in plants, food, and in human nutrition. *Trends in Food Science and Technology* **15**: 19–38.

Suzan O Y and Sezai E. 2011. Antibacterial and antioxidant activity of fruits of some rose species from Turkey. *Romanian Biotechnological Letters* **16**(4): 6407–11.

Tanaka Y, Sasaki N and Ohmiya A. 2008. Biosynthesis of plant pigments: Anthocyanins, betalains and carotenoids. *Plant Journal* **54**: 733–49.

Wang H, Cao G and Prior R L. 1997. Oxygen radical absorbing capacity of anthocyanins. *Journal of Agricultural and Food Chemistry* **45**: 304–9.

Wrolstad R E, Durst R W and Lee J. 2005. Tracking colour and pigment changes in anthocyanin products. *Trends Food and Science Technology* **16**: 423–8.