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Genotypic Differences for Anthocyanins in Different parts of Eggplant (*Solanum melongena* L.)

[*]Ankita Kumari[1], Neena Chawla[2] and Ajmer Singh Dhatt[3]

[1]Department of Animal Biochemistry, National Dairy Research Institute, Karnal, Haryana, India-132001
[2,3]Department of Vegetable Sciences, Punjab Agricultural University, Punjab, India-141004
[*]Corresponding Author: **Ankita Kumari**

Abstract

Anthocyanins are important class of secondary metabolites responsible for different colours of fruits. They are involved in protection from UV irradiation, insect attack in plants. Anthocyanins are thought to have anti-inflammatory, antiulcer, antioxidant and antimutagenic activities in humans. Brinjal is known to be a rich source of anthocyanins, responsible for purple colour of brinjal fruits. In present study, 50 genotypes of brinjal bearing fruits of different colours (purple, pink, green and white) were evaluated for anthocyanin content in peel, flesh part and whole fruit in fresh tissue in 2012 and 2013. In both years, the peel had highest anthocyanin content followed by whole fruit and flesh part. The fruits of green and white colour have low or negligible anthocyanin content in peel. The genotypes showed highest anthocyanin content in peel, flesh and whole fruit were SR-312 (purple), SR-308 (green) and SR-303 (purple) respectively. There was a negative correlation between weight of fruit and anthocyanin content present in peel while there was a positive correlation between anthocyanin content in peel and whole fruit.

Keywords: brinjal, anthocyanins, peel, whole fruit, colour.

Introduction

Brinjal or eggplant (*Solanum melongena* L.) belongs to Solanaceae family and it is the most popular vegetable crop in the central, southern and south-east Asia and some African countries which thought to be originated from India. It is also known as aubergine, melanzana or garden egg. The unripe fruit of brinjal is primarily used as a cooking vegetable for the various dishes in different regions of the world. It is also used as raw material in pickle making and dehydration industries. It is highly recommended to the patients with liver complaints.

Brinjal varied in growth habit, floral morphology and produces fruits of many shapes, sizes and colours. Colour varies from purple, white and green and the combination of these three. The shapes of brinjal can be similar to egg, sausage or pear and its weight can be varied from around 20 to over 400 g (Hanson *et al*., 2006).

Anthocyanins are the main class of flavonoids which give different colour to fruits, vegetables and vegetative parts of plants are the main phenolic compounds in brinjal (Mazza *et al*., 2004). Nasunin (cyanidin delphinidin 3-(p-coumaroylrutinoside) 5-glucoside is thought to be major anthocyanin present in peel of purple brinjal but not in white and green (Sakamura *et al*., 1963). Depending upon the genetic and environmental factors the concentration and composition of anthocyanins varies in plants

(Mohr *et al*., 1995). The most significant function of anthocyanins is their ability to impart colour to the plants or plant products in which they occur. Anthocyanins have anti-inflammatory, antiulcer, antioxidant, radical scavenging activities in humans (Wagner 1985; Cristoni and Magistretti 1987; Tsuda *et al.*, 1994). Because of these properties anthocyanins can be used for pharmacological and therapeutic purposes, so these can be referred as "Nutraceuticals".

The objective of this study was to screen the brinjal genotypes of different colours for anthocyanin content from peel, flesh and whole fruit and to determine whether the anthocyanin content was varied with the weight of fruit or not.

Materials and Methods

Collection of samples

Fifty genotypes of brinjal were cultivated under natural conditions at Vegetable Research Farm, Punjab Agricultural University, Ludhiana. The samples were obtained from Department of Vegetable Science, Punjab Agricultural University, Ludhiana, India. Brinjal fruits were harvested at maturity and were collected in 2012 and 2013.

Pre-treatment of samples

For the estimation of anthocyanins from different parts of fruit, the peel, flesh was manually separated with sharp knife. For the estimation of anthocyanins from whole fruit, the whole fruit was crushed in grinder and homogenized fruit was used for estimation.

Extraction

Each of samples from different parts (peel, flesh and whole fruit) were extracted with 10 ml of 1% HCl (w/v) in methanol for overnight at 4˚C. The acid lowers the pH of extraction solution and prevent the degradation of non-acylated anthocyanin pigment. Extract was filtered and used for the estimation.

Determination of anthocyanins

The anthocyanin content was measured spectrophotometrically as described by Rabino *et al*., (1977). The absorbance of extracts, clarified by filtration, was measured at 530 nm and 657 nm in spectrophotometer. The anthocyanin content of the extracts was presented as A_{530}-0.33A_{657}. This formula used to correct for the contribution of Chlorophyll and its degradation products in acid solution to the absorbance of the extracts at 530 nm. Results were expressed as mg cyanidin-3-glucoside equivalent per 100 g of FW (Fresh weight).

Statistical Analysis

Statistical analysis was performed in triplicate for each genotype. Data are presented as mean±SD. The variance analysis and significant differences among the means were analyzed with two-way analysis of variance (ANOVA) by using CPCS software version 1.0.

Results

50 genotypes of brinjal were selected for the analysis of anthocyanins content in two years i.e 2012 and 2013. The genotypes of brinjal under study were having different colours namely purple, pink, green, green with white streaks and pure white (Table 1).

Anthocyanins were extracted from peel, flesh part and whole fruit of various brinjal genotypes in acidified methanol and variation in anthocyanin content is reported for years 2012 and 2013. Genotypes having purple fruits have the highest content in their peel followed by genotypes having pink fruits. Brinjal genotypes having white and green fruits have very low or negligible anthocyanin content in peel, even sometimes it could not be detected. The anthocyanin content was found in the range of 0.04-113.93 mg/100g in 2012 and 0.05-109.02 mg/100g in 2013. The anthocyanins were not detected in BL-2001-1-2, G-401, G-409, G-412, G-415 and G-418 in two years. Anthocyanin content within two years was statistically not significant. In flesh part of selected brinjal genotypes, anthocyanin content was found in the range of 0.01-9.89 mg/100g in 2012 and in range of 0.03-6.84 mg/100g in 2013. In 2012, the whole fruit contained anthocyanins in the range of 0.55-88.24 mg/100g while in 2013, the content was found in the range of 1.87-88.91mg/100g.

The highest content of 88.24±4.6 mg/100g in SR-303 in both years (Table 2). On comparing the average content of anthocyanins in peel, flesh and whole fruit (Fig 1), it was found that peel contained the highest amount of anthocyanins followed by whole fruit and flesh part of brinjal. There was not much difference in average anthocyanin content in two years in each plant part.

TABLE 1: The brinjal genotypes used for study, their colour and weight of fruit.

Genotypes	Colour of the genotype	Weight of Fruit (g)	
		2012	2013
BL-2001-1-2	White	68.9	61.5
BL-201	Purple	57.0	90.1
BL-202	Purple	80.4	46.6
BL-204	Purple	74.9	136.1
BL-207	Purple	91.9	76.7
BL-214	Purple	76.7	74.7
BL-215	Purple	54.6	57.4
BL-219	Purple	40.1	126.6
BL-220	Purple	159.6	38.8
BLW-231	White	34.0	175.7
BLEND-11-WR-1	White	60.9	119.5
BLEND-11-WR-2	White, Purple strips	78.1	74.6
SR-308	Green	34.0	61.5
BR-104	Purple	251.3	112.7
BR-118	Purple	206.9	132.2
BR-133	Purple	132.4	105.8
BRG-111	Pink	253.4	59.9
BRG-224	Pink	69.6	45.9
G-401	Green	111.6	217.7
G-402	Green	65.3	157.2
G-403	Green	67.4	150.7
G-405	Green	118.0	113.0
G-407	Green	59.8	112.0
G-408	Green	70.4	63.7
G-409	Green	41.0	156.8
G-411	Green	160.5	97.1
G-412	Green	52.9	67.5
G-414	Green	241.1	132.2
G-415	Green	43.2	66.8
G-418	Green	80.5	65.7
MR-319	Purple	124.7	152.1
MR-320	Purple	90.5	86.5
P-71	Purple	51.9	155.9
SR-301	Purple	48.5	24.7
SR-302	Purple	29.5	38.2
SR-303	Purple	51.0	44.9
SR-304	Purple	42.7	48.1
SR-305	Purple	37.9	40.3
SR-306	Purple	45.1	50.8
SR-307	Purple	103.1	77.3
SR-309	Purple	63.3	67.2
SR-310	Purple	91.2	37.2
SR-311	Purple	71.6	60.5
SR-312	Purple	91.0	51.2
SR-313	Purple	73.4	52.9
SR-318	Purple	74.1	71.1
SRV-360-1	White	51.7	45.0
W-230-42-45-1	White	31.2	62.4
WL-502	White	95.7	82.0
WO-406	White	67.9	98.8

Data values are mean±S.D. of three replications, ND = Not Detected

TABLE 2: Anthocyanin content in peel, flesh part and whole fruit of different brinjal genotypes in 2012 and 2013.

Anthocyanin content (mg/100g)						
Genotypes	Peel		Flesh		Whole Fruit	
	2012	2013	2012	2013	2012	2013
BL-2001-1-2	ND	ND	0.14±0.2	0.29±0.1	4.91±0.6	4.59±0.5
BL-201	86.78±0.3	99.83±0.4	0.01±0.1	0.67±0.1	10.45±2.4	10.21±2.6
BL-202	99.95±0.1	98.73±0.0	0.02±0.1	0.03±0.1	24.06±0.1	25.09±0.0
BL-204	93.33±0.1	99.97±0.5	0.03±0.2	0.46±0.4	14.09±0.1	13.99±0.1
BL-207	94.23±2.8	99.95±1.4	0.26±0.4	0.79±0.5	42.35±4.6	41.88±4.5
BL-214	96.44±0.0	105.11±0.0	0.65±1.1	ND	5.09±0.2	6.48±0.1
BL-215	105.14±0.3	100.19±0.3	0.02±0.0	0.36±0.1	46.81±4.9	47.31±5.0
BL-219	98.39±1.8	104.15±1.4	0.02±0.0	ND	45.37±3.9	46.83±3.9
BL-220	98.56±0.3	103.07±0.2	0.66±1.1	2.21±0.3	12.18±0.1	10.79±0.2
BLW-231	0.07±0.1	0.05±0.0	0.32±0.5	0.75±0.1	5.47±1.0	4.97±0.7
BLEND-11-WR-1	3.34±0.6	3.10±0.5	0.69±1.1	2.24±0.3	4.22±0.5	3.69±0.4
BLEND-11-WR-2	0.04±0.0	0.18±0.1	0.19±0.3	0.41±0.0	4.12±0.4	3.43±0.4
SR-308	3.16±0.6	3.13±0.7	9.88±0.5	6.84±0.8	9.63±0.6	7.73±0.4
BR-104	93.01±0.2	99.30±0.4	0.23±0.3	0.13±0.1	26.33±0.6	25.75±0.4
BR-118	104.01±0.4	100.48±0.6	0.02±0.0	1.38±0.4	72.41±2.23	71.31±2.0
BR-133	92.49±0.0	87.89±25.1	0.18±0.1	0.24±0.1	9.37±0.1	9.83±0.1
BRG-111	57.41±0.1	62.00±0.0	ND	0.06±0.1	1.52±0.1	2.86±0.0
BRG-224	74.11±10.6	69.65±10.4	2.70±0.8	1.85±0.4	15.18±0.1	12.21±0.3
G-401	ND	ND	0.13±0.1	ND	4.56±1.2	2.60±1.6
G-402	1.25±0.2	ND	0.39±0.5	0.12±0.1	6.07±0.2	5.17±1.1
G-403	7.09±0.6	4.60±0.7	1.33±0.3	0.51±0.0	8.09±0.1	5.79±0.1
G-405	5.64±0.1	5.98±0.1	1.44±0.4	1.70±0.1	4.96±0.1	5.15±0.2
G-407	4.24±0.2	1.98±0.3	0.26±0.2	0.38±0.1	3.39±0.6	3.04±0.5
G-408	5.48±1.1	ND	0.28±0.2	0.18±0.1	4.10±0.7	2.16±0.8
G-409	ND	ND	ND	ND	3.97±0.1	4.09±0.2
G-411	46.34±1.3	45.24±1.0	1.15±0.1	0.82±0.4	30.98±0.1	30.78±0.1
G-412	ND	ND	0.27±0.2	0.88±0.1	0.55±0.3	1.87±0.3
G-414	ND	0.32±0.0	1.05±0.1	0.86±0.1	4.09±0.4	4.08±0.3
G-415	ND	ND	1.17±0.2	1.11±0.0	9.22±1.0	7.44±1.0
G-418	ND	ND	0.08±0.1	0.15±0.1	5.06±0.1	5.02±0.1
MR-319	106.67±2.2	103.49±1.4	1.42±0.6	1.73±0.1	32.37±0.8	29.51±0.5
MR-320	98.15±0.2	86.59±0.8	1.64±1.0	2.06±0.2	22.96±0.6	22.62±0.6
P-71	103.31±0.2	104.21±0.2	0.08±0.1	0.11±0.1	3.28±0.1	4.25±0.7
SR-301	104.21±1.8	106.06±1.6	1.52±0.4	1.65±0.2	19.20±0.9	18.89±0.8
SR-302	103.17±1.7	105.19±1.4	0.01±0.0	1.15±0.0	12.60±0.6	12.25±0.8
SR-303	104.00±1.4	103.33±0.9	1.38±0.3	1.17±0.3	88.24±4.6	88.91±4.6
SR-304	100.25±1.1	105.80±0.7	1.45±0.4	2.51±0.1	15.38±0.2	13.61±0.3
SR-305	97.83±0.2	99.84±0.8	0.44±0.3	1.59±0.2	19.53±0.9	19.03±0.9
SR-306	94.23±1.0	105.29±0.8	3.86±0.5	3.71±0.7	23.08±0.1	22.03±0.2
SR-307	105.17±2.4	104.90±2.9	0.30±0.2	0.38±0.0	20.08±0.1	18.38±0.3
SR-309	110.32±0.5	109.02±0.9	1.37±1.2	1.76±0.2	22.56±0.2	19.77±0.7
SR-310	107.56±2.8	103.97±2.5	1.72±1.1	1.97±0.3	11.73±0.1	10.97±0.5
SR-311	105.31±1.3	104.46±2.0	1.19±0.3	1.18±0.4	25.55±0.4	25.73±0.3
SR-312	113.81±1.9	107.70±1.3	2.17±0.2	1.63±0.4	42.40±2.6	39.55±2.4
SR-313	103.93±1.1	101.15±1.2	0.90±0.2	0.72±0.3	54.89±0.6	54.02±0.7
SR-318	112.19±0.7	105.62±0.8	3.55±0.6	2.93±0.8	66.20±0.3	63.81±0.6
SRV-360-1	ND	ND	1.04±0.1	0.96±0.1	8.57±0.1	6.30±0.0
W-230-42-45-1	2.77±0.7	3.01±0.6	1.22±0.2	1.23±0.3	6.49±0.0	7.24±0.6
WL-502	0.59±0.3	0.39±0.2	1.35±0.3	1.20±0.1	6.58±1.0	6.05±0.6
WO-406	0.39±0.1	0.96±0.2	0.99±0.1	1.19±0.2	4.03±0.5	3.46±0.4
MEAN	58.89	59.12	1.02	1.13	18.93	18.25

Data values are mean±S.D. of three replications, ND = Not Detected

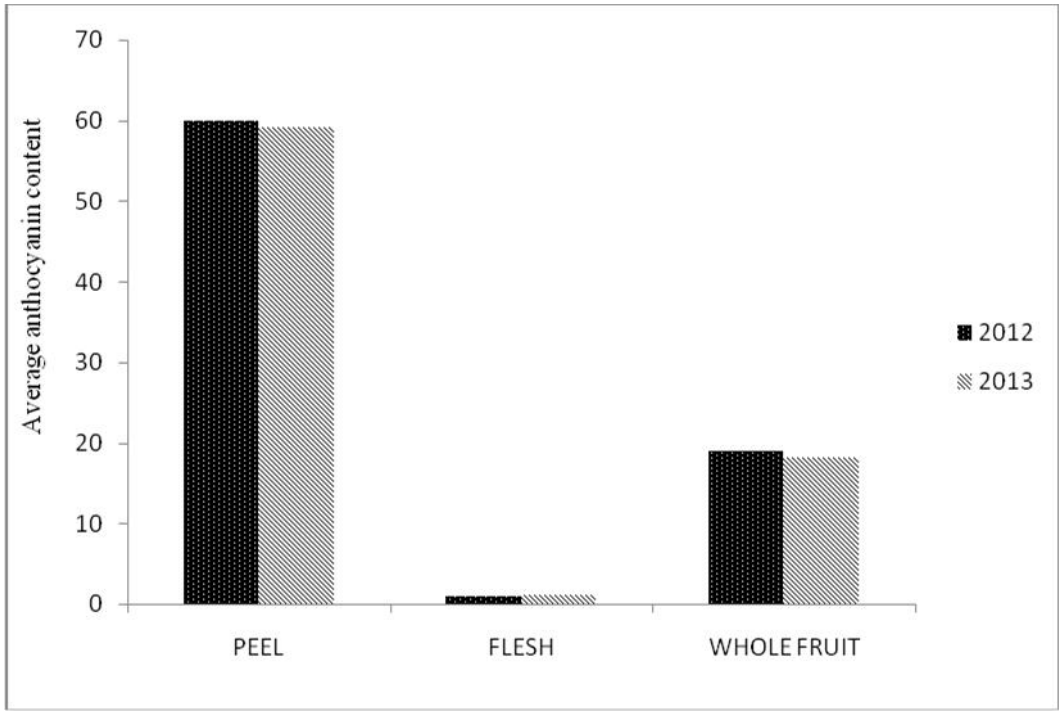

Fig 1: Frequency histogram showing average content of anthocyanins (mg/100g) in peel, flesh and whole fruit of various genotypes of brinjal in 2012 and 2013.

The correlation among various weight and anthocyanin content in peel, flesh and whole fruit among 50 genotypes was also estimated in 2012 and 2013. In 2012, there was a positive correlation between anthocyanins present in peel and whole fruit (0.604) which is significant at 1% level of significance. In 2013, there was negative correlation (-0.325) between weight of fruit and anthocyanins present in peel and was significant at 5% of level of significance. As similar of 2012, anthocyanins present in peel and whole fruit were significantly correlated (0.604) at 1% level of significance (Table 3).

TABLE 3: Correlation among various weight and anthocyanin content in peel, flesh and whole fruit in 2012 and 2013.

		Anthocyanins	
	Weight	**Peel**	**Flesh**
		2012	
Peel	0.121		
Flesh	-0.178	0.077	
Whole	0.090	0.604**	0.016
		2013	
Peel	-0.325*		
Flesh	-0.274	0.053	
Whole	-0.172	0.585**	0.084

Where * = significant at $p < 0.05$, ** = significant at $p < 0.01$

Discussion

Anthocyanins are naturally occurring pigments present in peel and to a lesser extent, in flesh of brinjal fruit and give purple and/or red colour to the fruit (Mazza *et al*., 2004). It was reported that peel tissue of brinjal had higher amount of anthocyanins than pulp tissue (Tomas-Barberan *et al*., 2001; Jhang *et al*., 2010). Same results are found in present study. Jung *et al*. (2011) found that the highest anthocyanin content in peel extract was 138.09 mg % while in present study highest anthocyanin content was 113.93 mg % in genotype SR-312. This confirmed that brinjal genotypes have high anthocyanin content in peel of purple fruits. The deep purple colour appearance has been reported to be due to the presence of delphidin-type pigments which are modified by acylation and total anthocyanins concentration (Sadilova *et al*., 2006). Another factor responsible for colour was reported by Nothmann *et al*. (1976) who suggested that the presence of chlorophylls could contribute to darkening.

Jung *et al*. (2011) found that the highest anthocyanin content in flesh extract was 2.29 mg %. In present study the highest anthocyanin content found to be 9.89 mg % in genotype SR-308 (green). The highest anthocyanin content in whole fruit was found in genotype SR-303 i.e. 88.91 mg %, in accordance with shown by Wu *et al*. (2006). There was variation in anthocyanin content of brinjal genotypes in 2012 and 2013 which may be due to genetic variation.

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Conflict of Interest

Authors have no coflict of interest with anyone.

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