EFFECTS OF TEMPERATURE AND GROWTH REGULATORS ON PIGMENTS OF GUAVA (*PSIDIUM GUAJAVA* L.) DURING RIPENING PERIOD IN JAMMU DISTRICT, J&K

Arti Sharma*, R. K. Sharma and Saleem Siddiqui

Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha-180009. E. Mail:drartisharma02@gmail.com

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ABSTRACT: A study was conducted to study the effect of temperature and growth regulators on pigments during ripening of guava in storage. Guava fruits of cv. Hisarsafeda and HisarSurkha were treated with Ethephon (250 ppm) and cytokinin (20 ppm) and were stored in BOD incubators maintained at two different temperatures *viz.* $30^0C\pm2^0C$ and $10^0C\pm2^0C$. Fruits were analysed for changes in fruit colour on alternate days. Chlorophyll content of guava fruits was observed to decrease with an increase in storage period. It was also observed that ethephon treated fruits were significantly lower in chlorophyll content (1.03 and 1.09 mg/100 cm^2 at 30^0C and 10^0C, respectively) than control fruit at both the storage temperatures while the fruits treated with cytokinin maintained significantly higher chlorophyll content (1.24 and 1.30 mg/100 cm^2 at 30^0C and 10^0C, respectively) over control at both the storage temperatures, irrespective of storage period and cultivars. Content of carotenoid pigments in guava fruits stored at 30 and 10^0C revealed an increasing trend in carotenoids with increasing storage period irrespective of treatment and cultivars. Maximum carotenoid content was recorded in guava fruits treated with ethephon (0.77 mg/100 cm^2) followed by untreated (0.73 mg/100 cm^2) and minimum in fruits treated with cytokinin (0.70 mg/100 cm^2) at 30^0C.

Guava (*Psidium guajava* L.) is a champion fruit belonging to family Myrtaceae and originated in tropical south America. It is one of the leading fruit crops in India due to wide adaptability to varying soil and climatic conditions (Sharma *et al*., 2013 and Gupta *et al.*,2016) . Guava is a perishable fruit and is susceptible to bruising and mechanical injuries. To reduce the percent losses in guava and to avoid glut, it becomes desirable to evolve technologies for prolonging its keeping quality through delaying softening process during ripening. Development of practical solution to the post harvest problems requires detailed understanding of biochemistry and molecular biology of fruit ripening. The various biochemical and molecular changes taking place in guava during ripening in isolation have been studied by many workers (Selvaraj*et al*., 1993; Jain *et al.*,2003,) Just like any other development process, fruit ripening is also under the control of plant growth regulators (McGlasson*et al.*, 1970; Bruinsma, 1983). Although all the five major growth regulators affect ripening in one way or the other, ethylene in routine is is referred to as the ripening hormone (Lelievre*et al.*, 1997). Ethephon (2, chloro-ethylphosphonic acid), an ethylene releasing chemical has been found a very effective growth regulator in accelerating the ripening and improving fruit quality in many climacteric fruits such as banana (Russo *et al*., 1968), apple (Wang *et al*., 2000), mango (Chundawat*et al.*, 1973b) and guava (Singh *et al.*, 1979), as well as in non-climacteric fruits such as in grape (Singh *et al.*, 1979). Cytokinins are derivatives of adenine, capable of inducing cell division. Cytokinin (kinetin or 6-furfurylamino-purine) is commercially used for delaying ripening in fruits.

Storage temperature has dramatic effect on ripening behaviour and quality of fruit. To understand ripening behaviour of a fruit, it is necessary to study its ripening process at different temperatures. Yonemoto*et al.* (2002) studied changes in respiration and ethylene production in white sapote cv. yellow fruits stored at 1, 5, 10, 15, 20, 25, 30 and 35^0C. The respiration peaked on the fourth day after storage at 35^0C and on the sixth day after storage at 15, 20, 25 and 30^0C. However, fruits stored below 10^0C did not show distinct respiration peak, no ethylene production and a low respiration rate were induced during storage at 1^0C.

The guava hybrids 'HisarSafeda' (Allahabad Safeda x Seedless) and 'HisarSurkha' (Apple Colour x BanarasiSurkha) were developed at CCS Haryana Agricultural University, Hisar (Daulta*et al.*, 1998). The demand of these hybrids is increasing among growers, due to its superiority over standard cultivars in terms of yield and quality. With all these facts in mind present experiment was designed to study the effect of

temperature and growth regulators on pigments of guava during ripening.

MATERIAL AND METHODS

The present investigation entitled was carried out on rainy and winter season guava crop at Post Harvest Laboratory of Department of Horticulture, CCS HAU, Hisar.60 kg uniform size fruits of both the cvs. HisarSafeda and HisarSurkha were harvested at green mature stage from the trees of uniform size and age, from the Experimental Orchard of the department of Horticulture, CCS HAU, Hisar in the month of January. Fruits were divided into 3 lots of 20 kg each. One lot of fruits was kept as control. Out of the remaining two lots, one lot was treated with Ethephon (250 ppm) and the other lot with cytokinin (20 ppm) by dipping the fruits in the solutions for 15 minutes. After treatment, fruits were air dried and for each treatment again divided into 2 lots of 10 kg each and were packed into 2% perforated polythene bags. Similarly, untreated control fruits were also divided into 2 lots of 10 kg each and packed separately in 2% perforated polythene bags, and it served as control. All the treated as well as the control fruits were stored in BOD incubators maintained at two different temperatures *viz.* $30^0C \pm 2^0C$ and $10^0C \pm 2^0C$.Fruits were taken randomly from each replication and were analysed for changes in fruit colour on alternate days. Total chlorophyll and carotenoids were estimated in the fruits taken from different sampling stages by the method given by Wellburn (1994). The content of the pigments was expressed in terms of mg/100 square centimetre of peel.Data recorded was analysed by using completely randomized design (factorial). Data collected were subjected to statistical analysis as suggested by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

It is indicated from the data presented in Tables 1 and 2 that at both the temperatures, a declining trend of chlorophyll content of guava fruits was observed with an increase in storage period. It reduced from 1.39 mg/100 cm^2 on 0 day of storage to 0.86 mg/100 cm^2 on 4^{th} day of storage at 30^0C. At 10^0C, it reduced to 0.95 mg/100 cm^2 on 6^{th} day of storage from 1.39 mg/100 cm^2 on 0 day of storage, irrespective of treatment and cultivar.

All the interactions were non-significant statistically at both the temperatures except those between treatments x storage period at 30^0C. This loss in chlorophyll content may be attributed to an increased chlorophyll degrading enzymes activities such as chlorophylase and chlorophyll degrading peroxidase (Yamauchi and Hashinaga, 1992 and Yamauchi *et al.*, 1997) during development and ripening. Similar results were also reported in guava by Siqueira*et al.* (2011) and Hegde (2001).

It was also observed that ethephon treated fruits were significantly lower in chlorophyll content (1.03 and 1.09 mg/100 cm^2 at 30^0C and 10^0C, respectively) than control fruit at both the storage temperatures while the fruits treated with cytokinin maintained significantly higher chlorophyll content (1.24 and 1.30 mg/100 cm^2 at 30^0C and 10^0C, respectively) over control at both the storage temperatures, irrespective of storage period and cultivars.Ethephon treated fruits exhibited a higher loss of chlorophyll than untreated control fruits at both the storage temperatures (30^0C and 10^0C), whereas cytokinin helped to maintain higher chlorophyll content over control (Table 1 and 2). This have occurred due to accelerated degradation of chlorophyll by ethephon and delaying of senescence by cytokinin. These results are in accordance with the findings of Yamauchi *et al.* (1997) who related acceleration of chlorophyll degradation by ethylene treatment to action of enzyme chlorophyllase in response to ethylene treatment. Ethephon has been found responsible for chlorophyll destruction in other fruits also, such as mango (Ashwani*et al.*, 1995) and orange (Azab, 1995). Significant difference was observed in chlorophyll content of guava fruits obtained from cv. HisarSafeda and cv. HisarSurkha. Cultivar HisarSafeda retained higher chlorophyll content (1.24 and 1.30 mg/100 cm^2 at 30 and 10^0C, respectively) than cv. HisarSurkha (1.03 and 1.08 mg/100 cm^2 at 30^0C and 10^0C, respectively) irrespective of treatment and storage period.

Parallelly, Kamboj (1997) have also reported higher chlorophyll content in cv. HisarSafeda than cv. HisarSurkha.

A careful study conducted to evaluate the effect of various treatments on the content of carotenoid pigments in guava fruits stored at 30 and 10^0C revealed an increasing trend in carotenoids with increasing storage period irrespective of treatment and cultivars. Carotenoids increased from 0.67 mg/100 cm^2 on 0 day of storage at 30^0C to 0.81 mg/100 cm^2 on 4^{th} day of storage (Table 3). At 10^0C, this increase was from 0.67 mg/100 cm^2 on 0 day to 0.78 mg/100 cm^2 on 6^{th} day of storage (Table 4). This increase in carotenoid content in peel of guava fruits may be due to increased synthesis of carotenoids or unmasking of carotenoids by decrease in chlorophyll (Woodward, 1972). In the present study, both these factors i.e. synthesis of carotenoids and degradation of chlorophyll seem to be involved as there was significant increase in carotenoids content which means there was active synthesis of carotenoids

during ripening of guava fruit and also a progressive decrease was observed in cholorophyll content which helped in unmasking the carotenoid pigments already present in fruits. These observations are in agreement with the results of Jain *et al.*(2003) in guava cv. Banarsi Sukha and Selvaraj and Raja (2000) in Kagzi lime. However these results are in contradiction to the findings of Selvaraj*et al.* (1999) who observed a decrease in carotenoid content of guava fruits of cvs. Allahabad Safeda and Sardar with advancement of ripening.

Maximum carotenoid content was recorded in guava fruits treated with ethephon (0.77 mg/100 cm^2) followed by untreated (0.73 mg/100 cm^2) and minimum in fruits treated with cytokinin (0.70 mg/100 cm^2) at 30^0C. More or less parallel observations were also recorded at 10^0C, with ethephon treated fruits showing maximum carotenoids (0.77 mg/100 cm^2) and minimum carotenoid content was exhibited by the fruits treated with cytokinin (0.70 mg/100 cm^2) irrespective of storage period and cultivar (Table 4).Ethephon treated fruits showed a faster increase and higher content of carotenoids than untreated fruits at both the temperatures. Contradictorily, the cytokinin treated fruits showed lower carotenoid content than control fruits. This could be explained by the fact that ethephon might have accelerated chlorophyll degradation which resulted into unmasking of more carotenoids whereas cytokinin is well known for keeping fruits green by delaying senescence. Earlier Medllicott*et al.* (1988) have also reported faster colour development in the external surface peel of fruits due to application of ethrel and recently Kulkarni*et al.* (2004) reported early development of yellow color (carotenoid) on surface peel and pulp of fruits due to ethrel dip treatment.

A significantly overall higher content of carotenoids was observed in cv. HisarSafeda (0.79 mg/100 cm^2at both 10^0C and 30^0C) as compared to cv. HisarSurkha (0.67 mg/100 cm^2 at both the temperatures). At 30^0C only the interactions between treatments x storage period were significant statistically all other interaction were non-significant whereas at 10^0C all the interactions were non-significant statistically. Kamboj (1997) also observed higher carotenoids in cv. HisarSafeda than cv. HisarSurkha. The effect of temperature on ripening of guava fruits was evident by Quicker development of carotenoids in rainy season fruits in comparison to winter season fruits and in treated winter season fruits stored at 30^0C than those stored at 10^0C.

Table 1 : Effect of various treatments and storage period on the chlorophyll content (mg/100 cm^2) of guava fruits during ripening at 30^0C

Treatments	**Storage period (days)**									**Mean**
	0			**2**			**4**			
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	
Control	1.50	1.29	**1.39**	1.26	1.02	**1.14**	0.99	0.75	**0.87**	**1.13**
Ethephon	1.50	1.29	**1.39**	1.12	0.90	**1.01**	0.81	0.58	**0.69**	**1.03**
Cytokinin	1.50	1.29	**1.39**	1.41	1.20	**1.30**	1.10	0.96	**1.03**	**1.24**
Mean	**1.50**	**1.29**	**1.39**	**1.26**	**1.04**	**1.15**	**097**	**0.76**	**0.86**	

Treatments	**Variety**		**Mean**
	V_1	**V_2**	
Control	1.25	1.02	**1.13**
Ethephon	1.14	0.92	**1.03**
Cytokinin	1.34	1.15	**1.24**
Mean	**1.24**	**1.03**	
CD at 5%	Variety (V) = 0.10 V × T = NS V × T × S = NS	Treatments (T) = 0.09 V × S = NS	Storage period (S) = 0.08 T × S = 0.45

V_1 = HisarSafeda

V_2 = HisarSurkha

Table-2: Effect of various treatments and storage period on the chlorophyll content (mg/100 cm^2) of guava fruits during ripening at 10^0C

Treatments	**Storage period (days)**												**Mean**
	0			**2**			**4**			**6**			
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	
Control	1.50	1.29	**1.39**	1.42	1.16	**1.29**	1.27	1.00	**1.13**	1.01	0.88	**0.94**	**1.19**
Ethephon	1.50	1.29	**1.39**	1.32	1.11	**1.21**	1.09	0.86	**0.97**	0.89	0.65	**0.77**	**1.09**
Cytokinin	1.50	1.29	**1.39**	1.80	1.26	**1.37**	1.39	1.15	**1.27**	1.27	1.02	**1.14**	**1.30**
Mean	**1.50**	**1.29**	**1.39**	**1.41**	**1.18**	**1.29**	**1.25**	**1.00**	**1.12**	**1.06**	**0.85**	**0.95**	

Treatments	**Variety**		**Mean**
	V_1	**V_2**	
Control	1.30	1.08	**1.19**
Ethephon	1.20	0.98	**1.09**
Cytokinin	1.41	1.18	**1.30**
Mean	**1.30**	**1.08**	

CD at 5%			
	Variety (V) = 0.08	Treatments (T) = 0.09	Storage period (S) = 0.09
	V × T = NS	V × S = NS	T × S = NS
	V × T × S = NS		

V_1 = HisarSafeda

V_2 = HisarSurkha

Table 3 : Effect of various treatments and storage period on the carotenoid content (mg/100 cm^2) of guava fruits during ripening at 30^0C

Treatments	**Storage period (days)**									**Mean**
	0			**2**			**4**			
	V_1	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	**V_1**	**V_2**	**Mean**	
Control	0.73	0.61	**0.67**	0.80	0.60	**0.73**	0.85	0.72	**0.78**	**0.73**
Ethephon	0.73	0.61	**0.67**	0.85	0.72	**0.78**	0.91	0.83	**0.87**	**0.77**
Cytokinin	0.73	0.61	**0.67**	0.75	0.63	**0.69**	0.80	0.67	**0.73**	**0.70**
Mean	**0.73**	**0.61**	**0.67**	**0.80**	**0.67**	**0.73**	**0.85**	**0.76**	**0.81**	

Treatments	**Variety**		**Mean**
	V_1	**V_2**	
Control	0.79	0.66	**0.73**
Ethephon	0.83	0.72	**0.77**
Cytokinin	0.76	0.64	**0.70**
Mean	**0.79**	**0.67**	
CD at 5%	Variety (V) = 0.01 V × T = NS V × T × S = NS	Treatments (T) = 0.02 V × S = NS	Storage period = 0.02 T × S = NS

V_1 = HisarSafeda

V_2 = HisarSurkha

Table 4 : Effect of various treatments and storage period on the carotenoid content (mg/100 cm^2) of guava fruits during ripening at 10^0C

Treatments	Storage period (days)												Mean
	0			2			4			6			
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	
Control	0.73	0.61	**0.67**	0.78	0.64	**0.71**	0.81	0.70	**0.75**	0.84	0.73	**0.78**	**0.73**
Ethephon	0.73	0.61	**0.67**	0.80	0.69	**0.74**	0.84	0.74	**0.79**	0.87	0.77	**0.82**	**0.76**
Cytokinin	0.73	0.61	**0.67**	0.74	0.62	**0.68**	0.70	0.65	**0.71**	0.80	0.70	**0.75**	**0.70**
Mean	**0.73**	**0.61**	**0.67**	**0.70**	**0.65**	**0.71**	**0.81**	**0.70**	**0.75**	**0.84**	**0.73**	**0.78**	

Treatments	Variety		Mean
	V_1	V_2	
Control	0.79	0.67	**0.73**
Ethephon	0.81	0.70	**0.76**
Cytokinin	0.76	0.65	**0.70**
Mean	**0.79**	**0.67**	
CD at 5%	Variety (V) = 1.01 V × T = NS V × T × S = NS	Treatments (T) = 0.02 V × S = NS	Storage period = 0.02 T × S = NS

V_1 = HisarSafeda

V_2 = HisarSurkha

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