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Compositional evaluation of guava (*Psidium guajava* L.) cv. L-49 during fruit growth and development

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Abstract
The present study was conducted to evaluate the physico-chemical changes in guava (*Psidium guajava* L.) fruit cv. L-49 at different stages of development and ripening. Fruit weight, fruit volume, fruit length and fruit diameter increased while specific gravity decreased at different stages after fruit set. Total soluble solid content, total sugar, reducing sugar, and non reducing sugar content were found to be increased while ascorbic acid and titratable acidity showed peculiarity in its content at different growth intervals.

Keywords: Guava fruit, cultivars, maturity, biochemical changes

Introduction
Guava (*Psidium guajava* L.) a member of family *Myrtaceae*, is an important fruit crop of tropical and subtropical regions.. It claims superiority and often called as "Poor Man's Apple" by virtue of its high nutritive value, rich in vitamin C content, antioxidants, dietary fibres and minerals. Guava fruit is consumed fresh as well as in the form of processed products (Patel *et al*. 2013) [19] Good nutrients and jelling property of guava with easy cultivation have made it important in traditional market as well as in domestic economy of tropical countries. Due to its climacteric nature, it get bruised easily and damaged during handling which in turn reduces its shelf life, transportation and storage difficult Therefore, the study was initiated with a view to evaluate certain indices based on physical and biochemical changes for judging maturity and quality of a guava fruit.

Materials and Methods
Fresh good quality guava fruit cv. L-49 was used as experimental material and procured from Main Experiment Station, Horticulture Farm, NDUAT, Kumarganj. The experimental site is located at Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.), at 42 Km away from Faizabad district headquarter. Geographically, it is situated at 26.47 degrees N latitude, 82.12 degrees E longitude and altitude of 113.0 metres from mean sea level. The selected trees were marked with metal tag for recording observations. The fully opened flowers were tagged samples were collected at 15 days interval after fruit setting to maturity. Fifteen fruits were randomly harvested from each replication at 30, 60, 90, 105, 120 and 150 days after fruit set for compositional analysis. The guava cultivar were free from blemishes, any visible sign of disease, infestation and physical injury.
Size of fruit viz. Length and diameter was measured with the help of vernier calliper and expressed in centimetre. The average value of fruit weight was calculated and reported in grams. Volume of fruits were measured by water displacement method and expressed in cubic centimeter. Regarding specific gravity the fruits were weighed on an electronic balance and then each fruit was immersed in a wide mouthed jar containing water. The amount of water displaced by the fruit was collected and measured by using a measuring cylinder (by water displacement method) and then calculated by the formula.
Total soluble solids of the juice was determined by using hand refractometer of 0-32 per cent range (Ranganna, 1977) [20]. Pectin content and acidity was determined by process as given by Ranganna (1977) [20]. The total sugar content was estimated by the method of Dubois *et al.* (1956) [5] using phenol reagent. Reducing sugar content was determined by the method of Miller (1959) [15]. The non reducing sugar content was obtained by subtraction of reducing sugar from total sugar. Ascorbic acid content in fresh fruit was determined by using 2,6-dichlorophoenol-indophenol dye as described by A.O.A.C. (1970) [1].

Results and Discussion

Physical changes

The data pertaining to the physical changes of guava fruit at different growth intervals is presented in Table 1. Physical parameters showed an increasing trend during growth intervals. Fruit weight increased from 15 days (42.80g) to 150 days (200.13g). Highest fruit volume (214.44cm$^{3)}$, fruit length (7.88cm), fruit diameter (8.25cm) were recorded at 150 days. The steady increase in weight and volume is due to the increase in moisture percentage and TSS content in fruits. The rapid increase from 90 to 150 days is contributed by increase in intercellular spaces, resulting in maximum accumulation of food substances and water with advancement of maturity. The results are in full agreement with Kirad *et al.* (2008) [13], El-Buluk *et al*. (1995), Yousf and Mohammed (1998) and Patel *et al*. (2005) [18].

Table 1: Changes in physical constituents in guava cultivar at different days after fruit set.

Days after fruit set	Weight (g)	Length (cm)	Diameter (cm)	Volume (cc^3)	Specific gravity
15	42.80	1.48	1.48	37.66	1.14
30	63.71	2.68	2.50	56.73	1.12
45	91.03	2.71	2.58	82.28	1.11
60	114.92	4.14	4.03	103.86	1.11
75	132.27	4.58	4.30	124.78	1.06
90	166.78	6.27	5.58	159.46	1.05
105	183.08	6.14	5.98	179.47	1.02
120	193.77	7.58	6.90	198.42	0.98
135	196.80	7.62	8.02	204.33	0.96
150	200.13	7.88	8.25	214.44	0.93
CD at 5 %	5.660	0.367	0.298	5.277	0.031

Specific gravity showed a declining trend at different growth intervals from 15 days to 150days and gradually decreases with the advancement of maturity, indicating a slight decrease in the solid matter content of the fruits. Lowest value was reported at 150 days (0.93%) after fruit set. It also has a direct relationship with the maturity index and general appearance of the fruits. The decrease in specific gravity in guava may be due to the increase of seed cavity of the fruit or partially due to increasing amount of intercellular spaces. The variations in specific gravity has also been reported by Kudachikar *et al*. (2001) [14] in mango fruit.

Biochemical changes

The data regarding biochemical changes have been given in Table 2.

Total soluble solids: It is observed from Table.2 that a gradual increase in TSS content was observed in guava cv. L-49 at different growth intervals(15 to 150 days) during development and ripening and ranges from (3.92-14.35%), the increase being rapid between 75 to 150 days. However, Singh and Jain (2007) [22] witnessed maximum TSS (14.93%) at 150 days. Agrawal *et al.* (2002) [3] exhibited 10.5 to 12.75%. Similar results were also supported Soares *et al.* (2007) [23], Wanichkul and Pengpon (2011) [24]. This inferences probably happened because of high consumption of sugars due to respiration rate. It is attributed mainly due to the hydrolysis of starch into sugar which subsequently increases the total soluble solid content (Nag *et al.*, 2011) [17].

Pectin content: Pectin content is correlated with the firmness and softening of fruit. Table 2. reveals that pectin content in guava cultivar increased significantly from 0.77 to 1.08% at 90 days and then decreased at 150 days (0.87%) after fruit setting. Dhillon *et al.* (1987) studied that pectin increased during early developmental stages but decreased as the fruits of guava varieties, Safeda and Sardar approached ripening. The results are also in close conformations with Selvaraj *et al.* (1999) [21]. In L-49, Jain *et al.* (2001) [12] reported that pectin content was found to be more abundant in mature green fruits (1.11%) which decreased continuously up to overripe stage, suggesting that mature green fruits could be good source for preparing commercial pectin. Similar results regarding pectin content is also found in guava cv. Banarsi Surkha by Jain *et al.* (2003) [11]. During ripening of fruits, the softening has been interpreted as the solubilisation of pectic substances from the middle lamella and hence an associated rise in soluble pectins.

Titratable acidity

Table.2 reveals that titratable acidity increased in the immature and intermediary stage of maturation and decreased in the maturity stage. Increase in titratable acidity show the formation of organic acids during maturation. These increases are associated with high concentration of undissociated organic acids, stored in the vacuole and the fruits use these acids as respiratory substrate. Abu-Goukh and Bashir (2003) [2] reported similar results to pink and white guava pulp. Similar findings are also supported by Nag *et al.* (2011) [17] and (Dolkar *et al*. 2017) [4].

Table 2: Changes in bio-chemical constituents in guava cultivar at different days after fruit set.

Days after fruit set	TSS (%)	Pectin (%)	Titratable acidity (%)	Total sugar content (%)	Reducing sugar (%)	Non-reducing sugar (%)	Ascorbic acid (mg/100g)
15	3.92	0.77	0.24	2.59	1.47	1.12	27.03
30	5.42	0.81	0.31	3.20	1.61	1.78	61.78
45	6.56	0.84	0.34	3.49	2.23	1.26	83.56
60	8.07	0.93	0.44	4.04	2.51	1.53	92.15
75	9.80	0.98	0.48	4.54	2.82	1.72	131.17
90	10.23	1.08	0.50	6.04	3.79	2.26	149.21
105	12.37	0.98	0.52	7.18	4.68	2.50	170.26
120	13.52	0.90	0.43	8.08	5.35	2.73	195.76
135	14.17	0.87	0.33	8.57	5.75	2.82	195.43
150	14.35	0.87	0.31	8.73	5.87	2.68	194.00
CD at 5 %	0.710	0.080	0.087	0.504	0.489	0.714	4.060

Ascorbic acid content: The table exhibits peculiarity, as, ascorbic acid content in guava varieties firstly, increased from 15 days to 120 days (27.03mg/100g-195.76mg/100g) and then decreased from 135 days to 150 days (195.43mg/100g-

194.00mg/100g). The results are in close consonance with Ghosh *et al*. (1985) who noticed that the ascorbic acid content increased during the early growth stages but declined on attaining maturity. Hegde and Chharia (2004), Nag *et al.* (2011) [17] and Gull (2012) [9] also found same trend in guava cultivar. The gradual increase in the contents of ascorbic acid during the period of development of the fruit seems to be directly related with the weight of fruit and due to oxidation of Vitamin C by ascorbic acid oxidase.

Sugar content

It is observed from the table that in contrast titratable acidity presence pattern in guava, total sugars, reducing sugars and non-reducing sugar showed increasing trend during late maturity in guava cultivar. Climacteric fruits, in particular, may show considerable changes in sugar content during fruit ripening. Total sugar increased till 150 days showing the highest value of 8.73%. Reducing sugar recorded highest (5.87%) at 150 days which may be due to conversion of non-reducing sugar. Non-reducing sugar increased till 150 days after fruit set recording the highest value of 2.68% which may be attributed to the hydrolysis of starch into simple sugars and also by continuous mobilization of sucrose from leaves to the fruit. Since various researchers as Nag *et al*. (2011) [17], Jain *et al*. (2001) [11], Buluk *et al*. (1997) [6] found total sugar increased slowly initially, thereafter, rapid increase during maturation. Wenkam (1990) [25], Mowlah and Itoo (1982) [16] who examined an increase in fructose during span of ripening.

Conclusion

From the above results, it may be concluded that transition in guava fruit cv. L-49 from 105-135 days stage is accompanied by major metabolic changes, it will be appropriate to harvest the fruits between this stage. This will facilitate safer handling and easy transportation of fruits and will also avoid postharvest losses. Among the various physico-chemical characters studied, colour, specific gravity and TSS could also be the used as indices for fixing the optimum stage of maturity for harvest.

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