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Growth and developmental changes of cape gooseberry (*Physalis peruviana* L.) fruits

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ABSTRACT : Cape gooseberry (*Physalis peruviana* L.) is a solanaceous fruit grown for edible fruits, being eaten fresh, as dessert, appetizer, or dish decorator and can also be prepared in elaborate dishes in cakes, or used in making jams, sauces etc. Growth and developmental changes were studied from anthesis to harvesting stage (1 week to 8 weeks from anthesis) in cape gooseberry fruits of genotype CITH-CGB-20, one of the promising genotype of this region. During over 8 week growth period the proportion of fruit weight to that of calyx (husk) decreased linearly (1.3 g at one week to 20.81 g at eight week). The water content of the fruit pulp increased slightly during development. The water content of the calyx varied considerably, increasing during first four weeks of development and then decreased as fruit matures or begins to ripe/yellow. Changes in fruit firmness varied significantly during development stages, it increases rapidly during 2 – 3 weeks and 5 – 7 weeks stage. Fruit pulp showed gradual increase in TSS ^{0}Brix from 0.43 (1 week) to 4.177 (6 week) and rapidly to 8.253 (8 week stage). The acidity showed a slow increase during first 6 weeks (0.324 to 0.365%) and increased rapidly during 6-8 week of development (0.521). Ascorbic acid showed double sigmoid pattern and there was rapid change during 2-4 week of anthesis (5.880 to 8.380 mg/100g) and from 6-7 weeks of anthesis (8.677 to 10.717 mg/100g). Chlorophyll content showed moderate decrease during 1-5 week of anthesis (5.0 to 4.0mg/100g), whereas, decrease was rapid in later stages of development and reached 1.00 mg/100g at 8 week after anthesis. Carotenoids increased gradually in fruits from 0.213-1.617 mg/100g. Cape gooseberry may be harvested commercially (horticulture maturity) when the fruits are well formed and substantially filled the calyx, may be 6-8 weeks after anthesis.

KEY WORDS : Cape gooseberry, Composition, Fruit development, Physical characters, Quality

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Cape gooseberry (*Physalis peruviana* L.) is herbaceous solanaceous crop grown for edible fruits. It has highly significance for diversification in market with fresh production. It is usually cultivated as short cycle (3-4 months) annual crop but in absence of frost it can be perennial. In its region of origin it is grown in a wide altitude range from sea level to 3200m, with an intense solar radiation to humid and cloudy environment. (Neuz *et al.,* 1999**).** It is indigenous to South America but was cultivated in South Africa in the region of Cape of Good Hope during 19th century imparting the common name, "Cape gooseberry." It is mainly grown in the region of its origin and in India, S. Africa and Australia Huwaii (Fischer *et al*., 1990; Chattopadhaya, 1996). It can be successfully grown and set fruit without problems if the minimum temperature is above 50 C (Peron *et al.,* 1989, Prohens and Neuz, 1994). Fruits of cape gooseberry are small 1-3.5 cm diameter: very juicy, aromatic yellow orange round berry at maturity contains many tiny seeds and is covered by large acrescent papery epicylx (Chattopadhyay, 1996), which gives them shape of a bladder. The fruit is tasty, having very good storability and attractive shape, determines it as a prospective crop for diversification in the temperate region. The fruit can be eaten raw, as a dessert, as an appetizer or as dish decorator. It can also be prepared in elaborated dishes in cakes or used in making jams etc. (National Research Council, 1989, Majumdar, 1979). It is high in vitamin A, B_1, B_2, B_{12}, C and poly- phenols

(Brazanti and Manaresi, 1980; Sarangi *et al*., 1989). The increasing demand of this fruit in the exotic fruit markets gives good prospective for the expansion of cape gooseberry as a new cash crop. Many 'types' and some named varieties are cultivated producing berries which vary in size, colour and flavour.

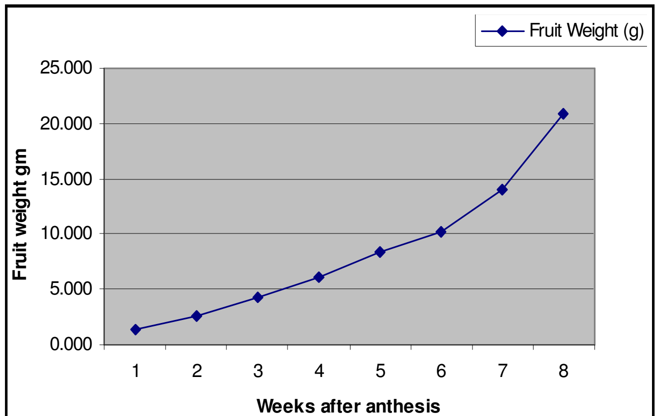
Fruits of Cape gooseberry are harvested and consumed when the husk has dreid and the berry is ripe and sweet (Tindall, 1983). The fruits are usually picked from the plants by hand every 2-3 weeks, although some of the growers prefer to shake the plants and gather the fallen fruits from the ground in order to obtain those of more uniform maturity. The fruit of cape gooseberry may also be picked partially green and allow to ripe, but decoding this stage is of great importance to get sweet as on plant ripened fruit (Trinchero Gustavo *et al*., 1999). In commercial market fruits of different stages of development may be harvested and marketed together. The intensity of greenish yellow colour of the fruit and partial dying of the calyx are of quality criteria. Most of the studies in cape gooseberry have focused on genetic and breeding (Leiva Brando *et al.,* 2001), cultural practices (Klinac, 1986; Wolf, 1991; Chattopadhya, 1996; Prohens and Nuez, 1994; Prohens *et al.,* 2004, Basra, 1999.) and plant developmental studies. Economic cultivation of fruit cultivars for obtaining marketable fruits every year largely depends upon the morphological events like flower bud formation, flowering, pollination, fertilization, fruit setting and fruit maturation. The present study was taken on changes during growth and development of cape gooseberry fruits under temperate conditions.

RESEARCH METHODS

Plants (four rows of 60 plants each of locally collected genotype (CITH CGB-20) were grown at a planting distance of 30 x 30 cm during summer season (April-August 2010) using normal and uniform cultural practices at Central Institute of Temperate Horticulture, Srinagar, J & K. Flowers at anthesis were tagged over an 8 week period (10 flowers on 40 plants/ week^{-1}) and fruits of all stages of development were harvested randomly from the plot at the same time. Fruits were weighed, husk removed and divided into three replications of 10 fruits each per developmental stages. Fruit firmness was determined using fruit firm tester (FF Fruit Firm Tester Yashica). Total soluble solids were calculated by digital refractometer. Titrable acidity was calculated as maleic acid after titration with 0.1N NaOH (AOAC, 1990). Ascorbic acid and carotene content at different stages were determined as methods described by Rangana (1986). The experiment was conducted under RBD and pooled data of two years was analysed as per the method suggested by Panse and Sukhatme (1985).

RESEARCH FINDINGS AND DISCUSSION

The cape gooseberry grew rapidly over 8 weeks developmental period increasing from 1.320 g at 1 week to 20.81 g at 8 week (Fig. 1). The proportion of fruit weight attributable to the calyx (husk) decreased steadily over the same period (Fig.2). During the developmental stage fruit shape was almost constant during the development, because increase in length and diameter paralleled each other (Fig. 3, 4). The water content of fruit pulp increased slightly during



Data are the averages and SD of three replications

Fig. 1 : Changes in fruit weight

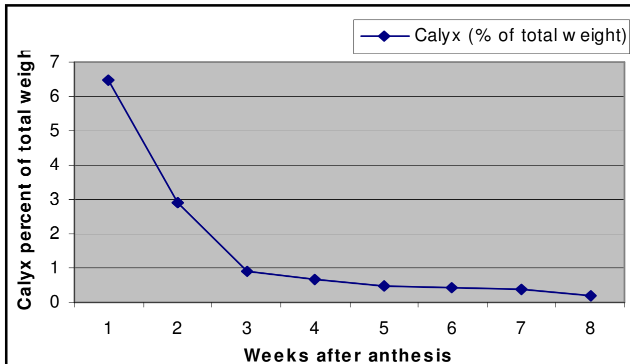


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Fig. 2 : Changes in calyx propotion

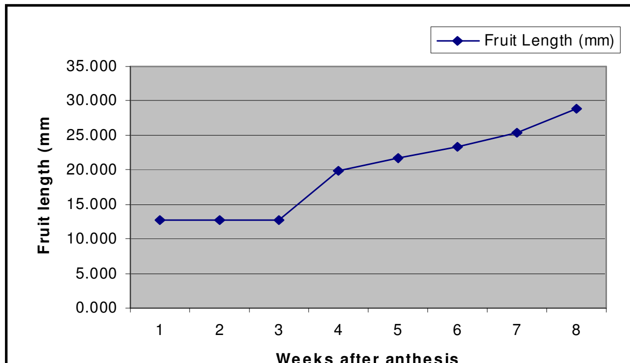

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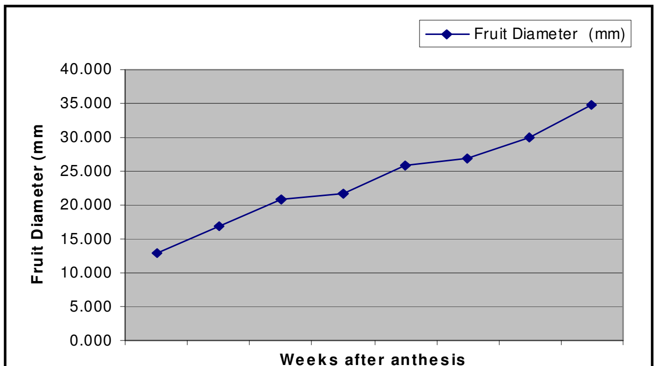
Fig. 3 : Changes in fruit length

development (Fig. 5) and, therefore, compositional data were expressed solely on a fresh weight basis. The water content of the calyx varied considerably, increasing during first 4 weeks of development to a maximum of 81 per cent and then decreased as the fruit matures and begins to ripen or yellow (Fig. 5). Similar trend in fruit weight, size and shape changes were also reported by (Cantawell *et al*., 1992) in case of husk tomato. Papov (2010) reported significant co-relation between agro climatic conditions and methods of cultivation with development of fruit of cape gooseberry. Adams *et al.* (2001) reported that development of tomato fruit is more sensitive to elevated temperatures in their later stages of maturation. Changes in fruit firmness varied significantly during the growth and development (Fig. 6). There was rapid increase in firmness from 2-3 weeks after anthesis and from 3-5 week it showed gradual increase, whereas, from 5 to 7th week there was againrapid increase in firmness.

The TSS content of fruit pulp increased significantly during the growth and developmental stages and increased gradually from 0.43 °Brix at 1 week to 4.717 °Brix at 6 week (Fig.5, 7) and thereafter rapidly increased to 8.253 at 8 week stage. Rapid increase in TSS during late stage of growth and development of fruit was also shown by Cantawell *et al.* (1992). Increase in TSS of Cape gooseberry fruits during developmental stages was also reported by Majumder and Majumdar (2002). Total pectic substances of the fruits rise with increase in TSS, which is indication of synthesis of new cell wall material during fruit growth (Tsantili, 1990).

During first week to 6 week after anthesis titrable acidity increased at slow rate *i.e.* 0.324 to 0.365 per cent, respectively and there after increased rapidly during later stages of development *i.e.* 6-8 week and reached up to 0.521 at 8 week stage. This may correspond to increase in pH of the fruit pulp at different developmental stages (Fig. 8). The findings are in line with findings of Cantawell *et al.* (1992) reported incase of developmental studies of husk tomato.

Changes in ascorbic acid showed sigmoid pattern, and it was rapid change during 2-4 weeks of anthesis (5.880 to 8.380 mg/100g) and from 6-7 week of anthesis (8.677 to 10.717 mg/100g). These are two critical stages (Fig. 9) where the



Data are the averages and SD of three replications

Fig. 4 : Changes in fruit diameter (mm)

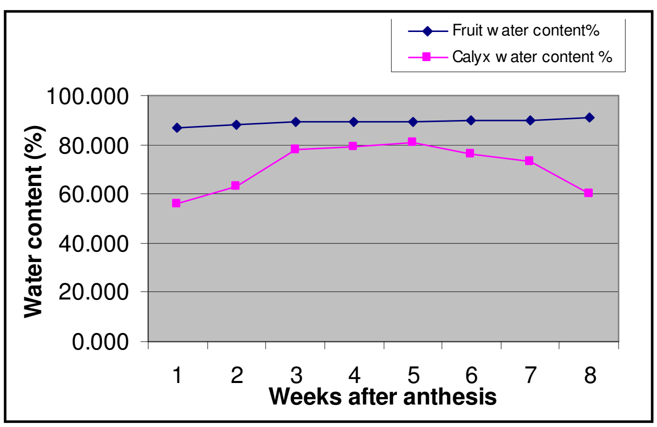


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Fig. 5 : Changes in fruit and calayx water content

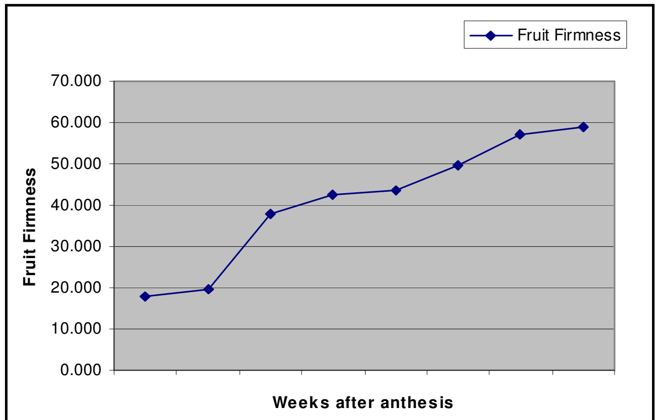

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Fig. 6 : Changes in fruit firmness

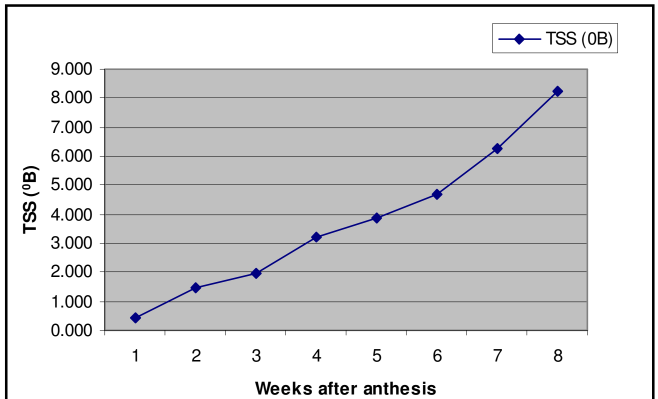

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Fig. 7 : Changes in TSS (^{0}B)

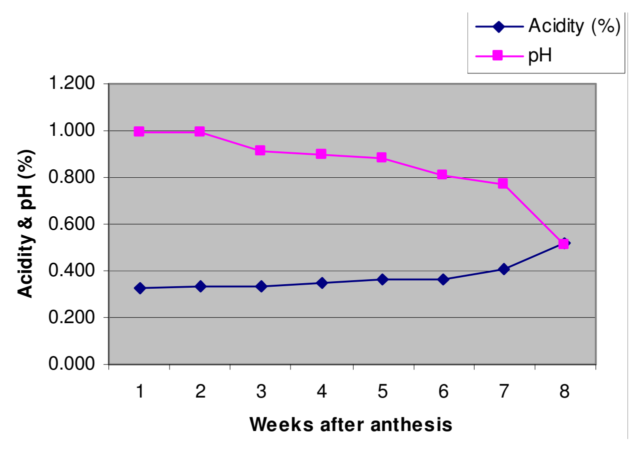

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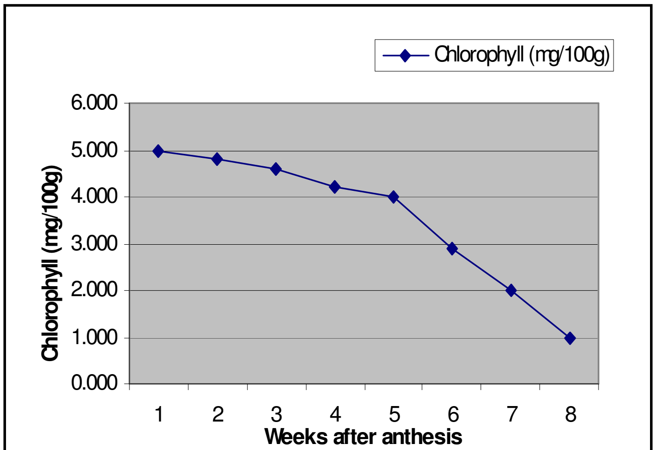
Fig. 8 : Changes in acidity and pH (%)



Data are the averages and SD of three replications

Fig. 10 : Changes in chlorophyll (mg/100g)

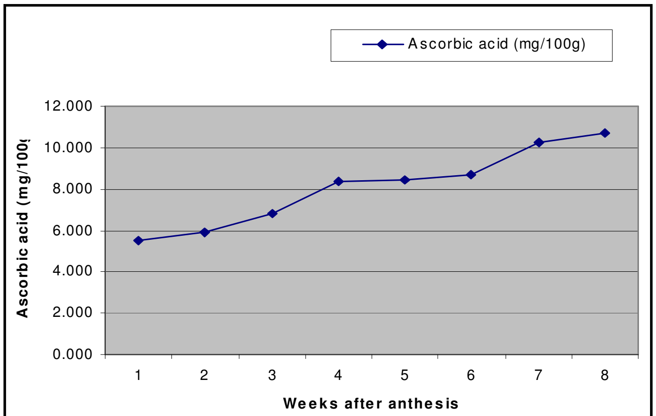


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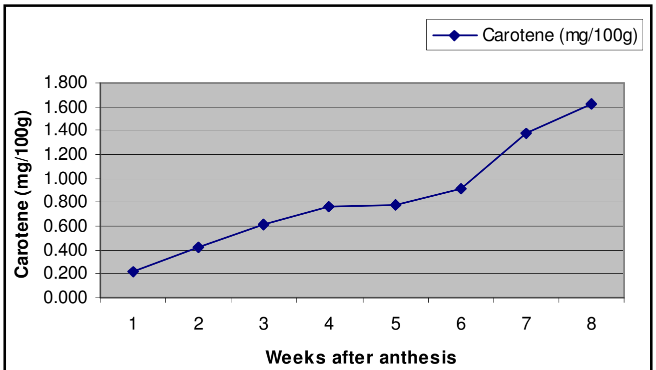
Fig. 9 : Changes in ascorbic acid (mg/100g)



Data are the averages and SD of three replications

Fig. 11 : Changes in carotene (mg/100g)

ascorbic acid contents at different developmental stages change at increasing rates.

Chlorophyll content of the fruit significantly decreased with development (Fig. 10). Chlorophyll content showed slight decrease during 1st to 5th week of anthesis (5.0 to 4.0 mg/100g), whereas, from 6-8th week stage the decrease was rapid and it reached to 1.0 mg/100 g at 8 week after anthesis. Yellowing of the fruits at later stage (7-8 week) of development coincides with lowest level of chlorophyll. Min Wu and Chieri Kubota (2008) reported gradual reduction of chlorophyll in tomato fruit with advanced stages, there after till the physiological maturation and reaches non detectable levels 7 weeks after anthesis. In case of carotenoids there was gradual increase in fruit from 0.213 (1st week) to 1.617 mg/100g (8th week after anthesis) (Fig. 11). Increasing changes in catotenoid contents during 1-8 weeks is contradictory to (Cantawell *et al*., 1992), who reported little decreasing trend during the developmental stages of husk of tomato fruits. Sunliang (2007) reported that in the ripening course of tomato fruits, the ß carotene decreased slightly and achieved highest value when fruits ripened completely. In general high sugar contents, redness of fruits, and firm texture are associated with prominence of rich flavour and bio chemical changes are influenced by growth, maturation and environment (Salunkhe *et al*., 1974). Cape gooseberry may be harvested commercially (horticultural maturity) when the fruits are well formed substantially filled the calyx, may be 6-8 weeks after anthesis. Fischer *et al.* (1998) reported that in cape gooseberry with fruit development: fruit size, weight and TSS: acidity ratio increased linearly up to dark orange stage, whereas, content of titrable acids decreased constantly and high TSS and beta carotene were found at high orange stage. Similar results showing 5-8 week stage appropriate for harvesting of husk tomato (*Physalis ixocarpa*) were also reported by Flores Minutti (1977); Cantawell *et al.* (1992). It is apparent that fruits harvested at different harvesting stages will differ significantly in composition, which can be expected to affect the flavour and other characteristics of the cape gooseberry fruits.

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