



FRUIT PHYSIOLOGY AND DEVELOPMENT STUDIES IN SOME ASIAN SOFT PEAR VARIETIES

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Received on 30 Oct., 2007, Revised on 28 March, 2008

SUMMARY

During growing stages of the pear fruit, the color changed to lighter shades of yellow- green and fruit shape was round- oblate in all the varieties at maturity. Fruit growth (length, diameter and weight) increased from fruit set to maturity in three distinct phases. Specific gravity, fruit firmness and number of lenticels/ cm² on fruit peel, showed a decreasing, while thickness and length of pedicel showed an increasing trend in all the varieties. Similarly, pulp and juice percentage and palatability rating increased and rag percentage decreased along with advancement in maturity. All the sugars (reducing, non-reducing and total) increased through out the fruit development, while the acid content decreased. Seed size and seed weight increased and seed color of all the varieties attained yellow- orange at maturity. All physical and chemical characters, except pedicel thickness and reducing sugars varied significantly among the tested varieties. Physical and chemical attributes of fruits mainly fruit weight, fruit diameter, fruit firmness and TSS were considered to determine the maturity stage of varieties. The varieties Shinseiki and Kosui attained maturity at 111-114 and Nijisseiki and Hosui at 114-118 days after full bloom. Based on the results on full bloom and days taken to maturity, harvesting time of the four varieties were as follows: Hosui = July 05-09, Nijisseiki = July 07-11, Shinseiki = July 11-14 and Kosui = July 12-15.

Key words: Fruit growth, maturity, palatability rating, soft pear varieties

INTRODUCTION

Asian pears (*Pyrus pyrifolia*) have the advantage of growing in sub- tropical region whereas the European pears (*Pyrus communis*) can grow only in temperate zones. Asian pears, mostly grown in Japan, China and Korea, are crisp and juicy with apple like flavor in contrast to the pear flavored, very soft and melting texture of European pears (Westwood 1978). An estimated 72 per cent of all known pear species are native to Asia. The USA houses 1500 clones, 40 per cent of these holding are Asian pear cultivars (Nee *et al.* 2002). The genetic base of Asian pears has been

enriched in North- West India with the introduction of soft and russeted in color varieties like Nijisseiki, Shinseiki, Kosui and Hosui from France. These varieties are early in maturity, soft textured and have strong flavor with better fruit quality (Sadhu and Chattopadhyay 2001). These varieties are showing promise under Ludhiana conditions. Before recommending any variety for release, it is necessary to study its fruit physiology during fruit development. Thus, keeping in view these facts, the present study was planned to find out an appropriate harvesting time of some Asian soft pear varieties.

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MATERIALS AND METHODS

The fruiting spurs were tagged on fifteen branches of four Asian soft pear varieties viz Nijisseiki, Shinseiki, Kosui and Hosui, all over the tree and three trees were selected for recording the observations. The physical observations were recorded from pea stage to color break stage at 7 days interval. After that the samples were collected for physico-chemical analysis at 5 days interval till the complete maturity achieved. The fruit size, fruit color, thickness and length of pedicel during the period of fruit development were recorded from the same tagged fruits. The other physical characteristics of fruit were recorded in the laboratory. The fruit characters, chemical characters and seed characters were analyzed after plucking the fruits, from the tree as per the standard procedures of AOAC (1990).

Fruit and seed color was recorded by using Royal Horticultural Society color chart (Wilson 1938), where every color has a given standard value. Fruit shape was recorded by visual observations. Fruit length & diameter and pedicel length & breadth were measured from the same fruits on the tree itself with the help of Vernier's Calliper's. The specific gravity of the fruit was measured by dividing the fruit weight with fruit volume. Fruit volume was determined by following water displacement method of Westwood (1978). Electronic balance was used to record fruit and seed weight. A thin layer of skin about 2 cm² was removed from two locations of each fruit and penetrometer was gently inserted into peeled pulp and applied force was recorded as Kg/ cm². Number of lenticels/ cm² on the skin of the fruit was counted with the help of magnified lens.

After weighing the sample of ten fruits, the fruit was peeled, the seeds were extracted and the pulp was separated. The weight of skin, seed core and flesh were recorded and pulp percentage was calculated. Juice was extracted from the pulp, weighed and expressed as percentage of the total fruit weight. The attributes of taste, appearance, texture, general eating quality and general acceptability of each variety were evaluated by a panel of four judges according to Hedonic scale (1-9 points). Total acids in fruit juice were determined by titrating 5 ml juice with 0.1 N sodium hydroxide and phenolphthalein indicator was used to get the end point.

TSS was measured with a hand refractometer in terms of degree brix. The readings were corrected with temperature correction chart. The sugars (total, reducing and non-reducing) were determined by the method of Lane and Eynon (AOAC 1990).

RESULTS AND DISCUSSION

Changes in color and growth parameters of the fruit: Color of the fruit was yellow-green (YG 144C) in Shinseiki, yellow-green (YG 144B) in Nijisseiki and Hosui and green (G 143C) in Kosui at 25 days after full bloom (DAFB). The color changed gradually to lighter shades through different shades of yellow-green when attaining maturity in all the varieties. Fruit color at the last sampling date (122 DAFB) was greenish-yellow (GY 160A) in Shinseiki, Kosui and Hosui and greenish-yellow (GY 161A) in Nijisseiki. The change in color towards lighter shades may be due to the synthesis of mainly carotenoides accompanied by the simultaneous loss of chlorophyll (Goodwin 1957). The fruit shape was oblong to round in all the varieties at initial stages of development which changed to round-oblate at harvest maturity. Griggs and Iwakiri (1977) reported globular to oblate shape in Shinseiki and round to oblate in Nijisseiki. However, Singh (1998) recorded that fruit shape of Kosui, Shinseiki and Hosui was round at maturity.

Length and diameter of the fruits increased continuously with fruit development in all the varieties (Fig. 1a and b). Fruit size increased from 1.84 x 1.72 cm to 4.12 x 4.50 cm in Shinseiki, 1.86 x 1.82 to 4.49 x 4.49 cm in Nijisseiki, 1.84 x 1.76 to 4.94 x 5.35 cm in Hosui and 1.65 x 1.67 to 4.74 x 5.21 cm in Kosui from 25 to 122 DAFB. However, there was no significant increase in fruit length at 111 DAFB in Shinseiki and Kosui and 114 DAFB in Hosui and Nijisseiki. No significant increase in fruit diameter was observed 114 DAFB in Shinseiki, 111 DAFB in Nijisseiki. Hosui produced the largest size fruit, followed by Kosui, Nijisseiki and Shinseiki. The growth of pear fruit can be divided into three distinct phases. It was rapid up to 60 days, very rapid between 60-106 days and plateau beyond 106 days until maturity in all the varieties. These 3 stages can be considered as phase 1, phase 2 and phase 3 of the cell division, pre enlargement, and enlargement stages identified by Yamaki and Matsuda

(1977). The endogenous auxin, gibberellin and cytokinin are responsible for the growth of fruits. More hormones are produced in younger fruits and the quantity declined with maturity (Singh 1997, Malik and Srivastava 1994).

Changes in physical characteristics of the fruit: All the varieties showed higher specific gravity (> 1.00) at early stages of fruit development, followed by a decreasing trend until maturity and the values became nearly constant during the last stages of harvesting (Fig. 1c). The specific gravity values were not significant among different varieties at 122 DAFB. The decrease in specific gravity can be attributed to relatively higher increase in fruit volume than the fruit weight with fruit development. Baker and Davis (1951) reported that the increase in fruit volume is more than that of fruit weight due to the increase in intercellular spaces during fruit development.

Fruit weight of all the varieties showed a continuous and significant increase until maturity (Fig. 1d). Percentage increase in weight from 67 to 122 DAFB in Shinseiki, Nijisseiki, Hosui and Kosui was 602, 431, 518 and 809, respectively and showed significant variation among varieties. The increase in weight was slow at the initial stages then became rapid at middle stage and again slowed down afterwards. The slow initial increase in weight might be the result of cell division and multiplication in this phase. The rapid increase in weight afterwards might be due to both faster increase in cell size and accumulation and storage of food material in cells of the mesocarp (Baker and Davis 1951).

A continuous decrease until fruit maturity was observed in pulp firmness in all the varieties (Fig. 1e). At the first record of 86 DAFB, it was more than 12 Kg/ cm² in all the four varieties, but significantly decreased when fruit attained maturity. Firmness in fruit is due to the insoluble pectin material in the cell wall and middle lamella resulting intercellular cementing and strengthening of the cell wall. The conversion of insoluble pectin into soluble forms decreases the firmness in fruits when it matures (Northcote 1958).

The number of lenticels/ cm² continuously decreased up to maturity in all the varieties (Fig. 1f). Number of lenticels in Hosui and Kosui did not show significant

decrease beyond 114 DAFB and the corresponding stage for Shinseiki and Nijisseiki was up to 122 DAFB. The number of lenticels varied significantly among the varieties at 122 DAFB, the highest being in Shinseiki. Griggs and Iwakiri (1977) described lenticels in Shinseiki as conspicuous and small to medium and in Nijisseiki as inconspicuous and small to medium.

Thickness of pedicel in all the varieties increased from 25 DAFB to around 100 DAFB, and thereafter it did not change (Fig. 1g). A significant increase in pedicel length was observed from 25 to 106 DAFB in Shinseiki and Kosui (Fig. 1h). It increased significantly up to 114

Fig. 1. Time course changes in a) fruit length, b) fruit diameter, c) specific gravity, d) fruit weight, e) fruit firmness, f) no. of lenticels, g) pedicel thickness, h) pedicel length, i) pulp percentage, j) rag percentage, during fruit development in pear varieties.

DAFB in Nijisseiki and up to 101 DAFB in Kosui. Variety Hosui showed the shortest pedicel length among the tested varieties. Griggs and Iwakiri (1977) also reported variation in pedicel length and diameter in Asian varieties.

The pulp percentage increased with the advancement of maturity (Fig. 1i). Pulp percentage was directly related with the increase in fruit growth and fruit weight. Pulp percentage was higher in Hosui as compared to other varieties at the time of fruit harvesting. Also, the juice percentage showed a significant increase from 91 DAFB to 114 DAFB in Nijisseiki, but it continued until 122 DAFB in Shinseiki, Hosui and Kosui (Fig. 2a). Little variation in juice content was observed in different varieties. The increase in pulp and juice percentage was also recorded in Punjab Beauty and Punjab Gold varieties of semi- soft pear during fruit development (Singh 2003). Rag (left over pulp after extraction of juice) percentage of the fruits was higher at early stages of fruit development and afterwards it showed a decreasing trend until maturity (Fig. 1j). It decreased significantly up to 114 DAFB in Nijisseiki, but remained nearly constant after 114 DAFB. However, in Shinseiki, Hosui and Kosui, rag percentage significantly decreased up to 122 DAFB. All the varieties had low percentage of rag at maturity, being lowest in Kosui. The increase in juice percentage with fruit maturity resulted in lower rag percentage.

All the varieties have shown significantly an increasing trend in palatability rating as fruit reaches maturity (Fig. 2b). Also, significant differences were noted in palatability rating in different varieties. Kosui recorded the highest score, followed by Nijisseiki. Palatability score does not depend on any single parameter, but is an indicator of many integrations and the eating quality of fruits depends upon the combination of characteristics such as flavor (taste and smell) and texture (feel) of the pulp (Kader 1985).

Changes in chemical characteristics of the fruit: The TSS content of the juice indicated by °brix showed a gradual increase until full maturity, in all the varieties (Fig. 2c). However, the TSS remained almost constant during the last phases of fruit development from 11 DAFB onward in Shinseiki, Hosui and Kosui. The

increase in TSS during fruit development is the result of degradation of starch and organic acids into soluble sugars (Dame *et al* 1956). The juice acidity continued to decrease in all the varieties during fruit growth and development (Fig. 2d). However, the decrease was significant only up to 118 DAFB in Shinseiki, up to 122 DAFB in Nijisseiki and Hosui and up to 101 DAFB in Kosui. The acidity remained constant 101 DAFB in Kosui. Tested varieties showed a significant variation in acidity at 122 DAFB. The decrease in acid content during maturation is the result of conversion of organic acids into soluble sugars (Dame *et al* 1956). Climatic and nutritional factors could have an influence on the acid content of fruits (Nitsch 1953).

During fruit development, TSS/ acid ratio increased continuously in all the varieties till maturity. The ratio in Shinseiki, Kosui and Nijisseiki increased from 91 DAFB to 118 DAFB and thereafter values remained stable. The TSS/ acid ratio increased significantly in Hosui from 91 DAFB to the last sampling date. It also showed a significant variation among all the varieties at 122 DAFB. The highest ratio was observed in Kosui and the lowest in Hosui. Aswapati and Uthaibathra (1990) also reported the highest TSS/ acid ratio in Kosui as compared to fifteen other Asian varieties.

All the four varieties showed an increase in reducing sugars from 91 to 122 DAFB during the development of fruits (Fig. 2e). The increase in reducing sugars was mainly due to hydrolysis of starch into sugars during maturation and ripening (Blaskhina 1978). The increase in non- reducing sugars also showed a significant increase during fruit development (Fig. 2f). No increase was observed at 122 DAFB in all the varieties. However total sugars continued to increase from 91 DAFB to harvest maturity (Fig. 2g). Total sugars recorded a significant variation among different varieties at 122 DAFB, maximum being in Hosui and minimum being in Nijisseiki. The observed increase in total sugars during fruit growth and development could be due to hydrolysis of starch into sugars.

Changes in seed characteristics of the fruit: A significant increase in seed weight was noted in all the varieties from 91 to 114 DAFB and remained nearly constant after 114 days (Fig. 2j). Final seed weight at

considered to determine the maturity stage of varieties. Nijisseiki and Hosui attained maturity at 114-118 DAFB and Kosui and Shinseiki at 111-114 DAFB. Based on the data on full bloom and days taken to maturity, harvesting time of the four varieties were as follows: Hosui = July 05-09, Nijisseiki = July 07-11, Shinseiki = July 11-14 and Kosui = July 12-15.

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Fig. 2. Time course changes in a) juice percentage, b) palatability rating, c) TSS, d) acidity, e) reducing sugars, f) non-reducing sugars, g) total sugars, h) seed length, i) seed diameter, j) seed weight, during fruit development in pear varieties.

122 DAFB showed significant differences among the varieties. The maximum final seed weight was noted in Nijisseiki and minimum in Shinseiki. Similarly, seed size also observed the same pattern to that of seed weight (Fig. 2h and i). The color of the seed was yellow orange in Shinseiki and Kosui, while it was yellow- green in Hosui and yellow in Nijisseiki at 91 DAFB. However, the seed color changed into yellow- orange at 122 DAFB in all the varieties. But, Singh (1998) reported that the seed color of Kosui and Hosui as brownish and as light-brown in Shinseiki at maturity.

Physical and chemical attributes of fruits mainly fruit weight, fruit diameter, fruit firmness and TSS were

FRUIT DEVELOPMENT IN ASIAN PEAR VARIETIES

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