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EFFECT OF STAGE OF MATURITY ON QUALITY AND SHELF LIFE OF 'PUNJAB BEAUTY' PEARS

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ABSTRACT
Harvest maturity has a significant effect on quality and storage life of pears as they are harvested during a relatively narrow range of fruit maturity. To further our understanding of the response of pears to different harvest times, 'Punjab Beauty' pears were harvested at three stages *i.e.* pre-optimum, optimum and post-optimum and stored in cold room at 0-1^{0}C and 90-95% RH. The fruits were evaluated for quality parameters after 30, 45, 60 and 75 days of storage. The post-cold storage shelf-life at ambient conditions (30.5 $\pm$ 2.5^{o}C and 80 $\pm$ 2.5 % RH) was studied after 3 and 6 days to assess the post cold storage behaviour of fruits. Results revealed an increase in the spoilage, physiological loss in weight, TSS: acid ratio with the advancement in maturity and storage period. The reducing sugars increased up to 60 days of storage and declined thereafter. However, the maximum sugars were recorded in late-harvested fruits. Shelf life studies showed minimum spoilage and maximum palatability rating in optimum stage harvested fruits. Thus, it can be concluded that pears harvested at optimum stage of maturity can be stored for 60 days in cold store with post-storage shelf life of three days at ambient temperature.

KEYWORDS: pear, harvesting stage, storage, maturity, fruit quality, palatability.

INTRODUCTION

Pear (*Pyrus communis* L.) is popular with the consumers for its unique fragrance, subtle aroma, sweetness, and crispness. In India, pear cultivation is mainly confined to the hills of north-west India. The superior cultivars have high chilling requirements and are being grown in higher reaches of Kashmir, Himachal Pradesh and Uttarakhand, whereas some low chilling types have been evaluated and were found to be suitable under sub-tropical conditions (Sandhu *et al.*, 2007). Semi-soft pear strain named 'Punjab Beauty' has gained popularity because of its distinguished organoleptic qualities. The fresh pear fruits are commonly used for table purposes as it has good eating quality with few stone cells. Commercial harvest of 'Punjab Beauty' may last for three weeks which implies that pears are picked at different degrees of maturation. Storability of pears is strictly dependent on the cultivar, fruit maturity during harvest and storage conditions (Elgar *et al*., 1997). Harvesting time is an important determinant for storage life. Fruits harvested at advanced maturity are more prone to mechanical injury, have short storage life and greater susceptibility to pathogens and physiological disorders (Juan *et al.*, 1999). In addition, careless harvesting characterised by immature and over mature fruit, is another serious cause of postharvest losses (Ingle *et al*., 2000). Kvikliene *et al*. (2011) reported that the effect of the harvest date on fruit quality and storability was significant up to 150 days of storage. After this date a fast decline of apple quality parameters was observed. Proper prediction for harvest maturity will also allow producers to plan for harvesting and marketing well in advance and capitalize on labour productivity. Thus, keeping in view the above facts, the main aim of the work was to determine optimal harvest date in pears, for maintaining the quality during cold storage and post cold storage at ambient temperature.

MATERIALS & METHODS

The studies were carried out in the Department of Horticulture and Punjab Horticultural Post-harvest Technology Centre PAU, Ludhiana. Pear fruits cv. 'Punjab Beauty' harvested at 3 different stages *i.e*., Pre-optimum (2nd week of July), Optimum (3rd week of July), and Post-optimum (1st week of August). The harvested were washed, air dried, packed in CFB boxes and stored at 0-1^{o}C and 90-95% RH in walk-in-cool chambers (Blue Star Company). The observations for various quality attributes were recorded at 30, 45, 60 and 75 days storage interval. After 60 days of storage, the fruits were kept at room temperature (30.5 $\pm$ 2.5^{o}C and 80 $\pm$ 2.5% RH) for 3 and 6 days to study the post cold storage life of fruits. The physiological loss in weight (PLW) was calculated on initial weight basis. The spoilage percentage of fruits was calculated on number basis, by counting the fruits that spoiled during storage in each box and results were expressed in percent. Organoleptic evaluation of the fruits was done by five judges on the basis of Hedonic scale (1 to 9points), on the basis of general appearance, taste and texture (Amerine *et al.*, 1965). The total soluble solids (TSS) were determined from fresh strained juice of fruits on each sampling date with the help of a hand refractometer (Erma, Japan make). The readings were corrected at 20°C and expressed as percentage soluble solids. The titratable acidity in juice as malic acid was

determined by titrating a known volume of juice with 0.1 N NaOH using phenolphthalein as an indicator. The TSS: acid ratio was calculated by dividing the values of TSS with that of corresponding values of acidity. The reducing sugars were determined by the method of Lane and Eynon (AOAC, 2000).

Statistical analysis

The experiment was laid out in completely randomized block design with factorial arrangement having three replications. Total samples analyzed were 36 for each set of experiment and each replication comprised of 2 kg fruits. The data of two seasons was pooled and subjected to analysis of variance (ANOVA) using SAS 9.3 (2011) to find out the significance of different treatments. The treatment combinations significant at $p<0.05$ were subjected to mean comparison using Tukey's HSD.

RESULTS & DISCUSSION

Spoilage

At the end of each storage interval, the spoilage loss was maximum in fruits harvested at later stage of maturity (Fig. 1A). The spoilage losses increased progressively with the increase in storage period. The maximum spoilage losses (10.48%) were recorded after 75 days of storage in fruits harvested at post-optimum stage while it was least (2.51%) after 30 days of storage in the fruit harvested at pre-optimum stage. Fruit decay loss due to rotting also increased as the storage period advances.

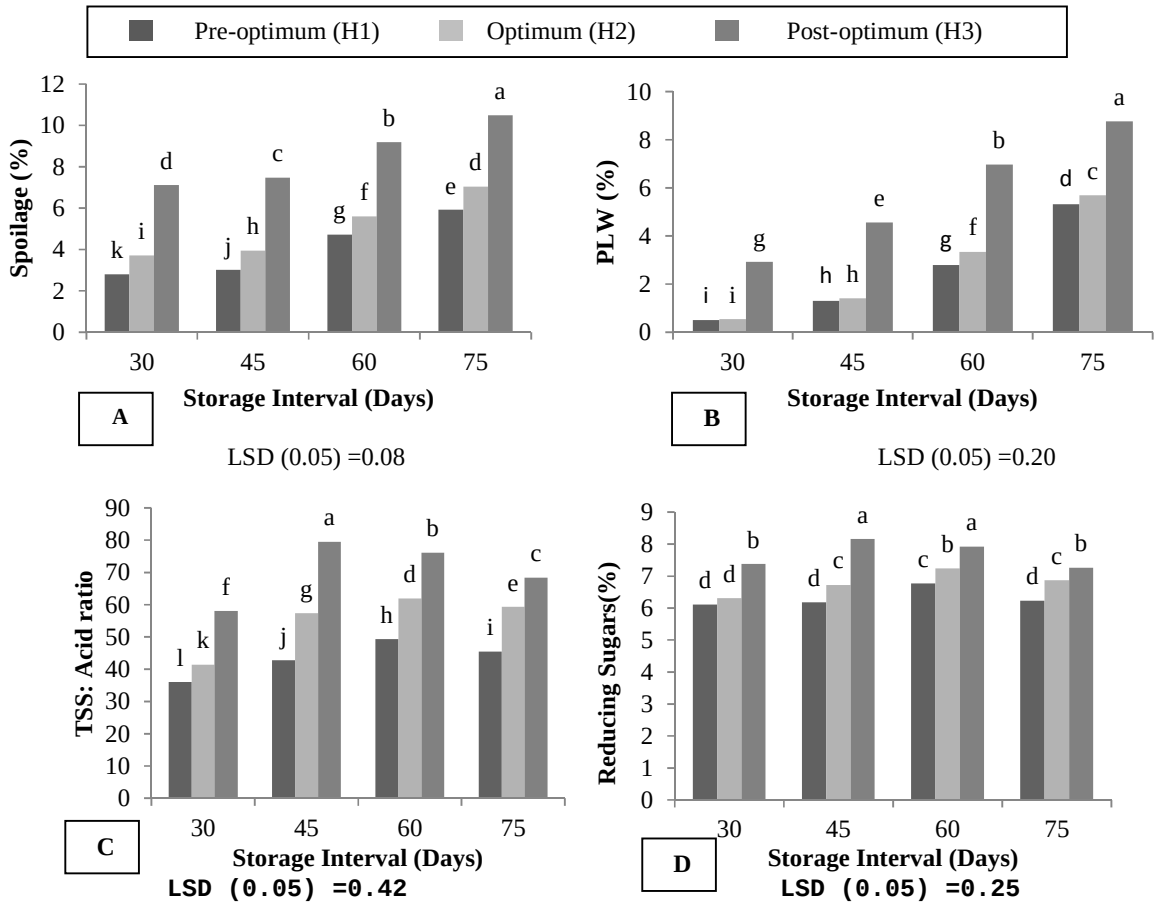

FIGURE 1. Effect of harvesting stage on spoilage percentage (A), physiological loss in weight (B), TSS/acid ratio(C) and reducing sugars (D) of pear fruits during storage at 0-1°C and 90-95% RH. Means followed by different superscript letters in the same column are significantly different by Tukey's test ($P<0.05$).

These findings substantiate the earlier reports on the aspect by Błaszczyk (2010) that delay in the harvest date resulted in fast softening of fruit, significant reduction of titratable acidity, and higher susceptibility to spoilage. Juan *et al.,* 1999 who reported that the spoilage increased with the delay in harvesting dates which might be due to increased respiration rate, enzymatic activities and dissolution of cell wall ultimately leading to softening and ripening of fruits and in the later stages of harvest maturity consequently caused rotting of fruits.

Physiological loss in weight

The third harvest had the highest total weight loss at all times during storage (Fig.1B), while pears harvested at early maturity (first harvest) had the lowest weight loss (less than 5 %) compared with the last harvest that lost more than 8 % of their weight after 75 days of cold storage. The results revealed that there was significantly less loss in weight in the fruits harvested earlier than those harvested later. The higher PLW in the fruits harvested at later stage of maturity could be due to higher respiration and transpiration losses with advancement of the harvest

maturity. The present findings are in agreement with the findings of Kaur *et al.,* (2013) and Ribeiro *et al.* (2003) in pears.

TSS: acid ratio

The TSS: acid ratio is the direct outcome of the sugar content and acidity in the fruits. It is the best criteria to determine the fruit quality. The ratio increased progressively with the advancement of harvesting time (Fig.1C). Fruits picked at first harvest date showed significantly lower TSS: acid ratio (36.05) compared to the last harvest date which showed the maximum TSS: acid ratio (70.76) after 30 days of storage. TSS: acid ratio increased progressively with the increase in storage period but showed a tendency to decline towards the later part of storage period. The increase in total soluble solids during storage up to 60 days may be attributed to numerous metabolic processes taking place in the fruits, preparing it for senescence. The hydrolysis of starch and pectins, yielding mono and disaccharides could be the reason for increase in TSS. However, this might be attributed to the fact that on complete hydrolysis of starch, no further increase in TSS occurs and consequently a decline in TSS is predictable as they are the primary substrates for respiration and are used by fruits in various metabolic activities (Wills *et al*., 1980). The decrease in titratable acidity with increase in storage duration was also reported by Bhakshi and Massodi (2009) in peach fruits which might be due to the conversion of acids into total sugars.

Reducing sugars content

The reducing sugars increased with increase in storage period upto 60 days and declined there (Fig.1D). The reducing sugars increased with delay in harvesting dates, but in fruits harvested at post-optimum stage, the total sugars decreased after 45 days of cold storage whereas the fruits harvested at optimum stage showed increase in total sugars up to 60 days of cold storage. However, after 75 days of cold storage, the sugars declined and this decline was more pronounced in fruits harvested at post-optimum stage which might be due to fermentation in overripe fruits which converted sugars into alcohols. Limei *et al.* (2011) reported that the latest picked pears showed higher sugars and serious internal browning and skin blackening due to their over ripeness.

Post-cold storage shelf life

The shelf life studies at ambient temperature and RH (30.5 $\pm$ 2.5^{o}C and 80 $\pm$ 2.5 % RH) for 3 and 6 days were conducted to study the behavior of fruits in retail market after 60 days of cold storage (Table 1).

TABLE 1. TSS: acid ratio, spoilage and palatability rating of pear fruits during post-cold storage ambient shelf life after 3 and 6 Days

Shelf life (Days)	Stages of maturity	TSS: Acid ratio	Spoilage (%)	Palatability rating
0	H1	49.32i	4.73f	6.89b
	H2	61.98f	5.59de	7.83a
	H3	82.11a	8.70b	6.27c
3	H1	58.95h	5.43e	6.24c
	H2	63.66e	6.16d	6.38c
	H3	71.59b	9.19b	5.37d
6	H1	60.92g	7.76c	5.14d
	H2	65.29d	8.56b	5.27d
	H3	69.48c	10.14a	4.11e
LSD at 5%		0.09	0.39	0.29

H1= pre-optimum, H2 = optimum, H3 = post-optimum stage of harvest. Means followed by different superscript letters in the same column are significantly different by Tukey's test (P<0.05).

The TSS: acid ratio of the fruits during ambient storage continued to increase in fruits of first and second harvest date up to 6 days at ambient temperature whereas in case of fruits harvested at post optimum stage of maturity the ratio followed a declining trend after 3 days at ambient temperature. The spoilage varied significantly with the harvesting dates during ambient storage for 3 and 6 days. The highest spoilage was recorded in fruits harvested at post-optimum stage of maturity which ranged from 9.19 to 10.14 percent for 3 and 6 days. The temperature at which a commodity is stored has a direct influence on its spoilage due to rots because the spoilage causing organisms also find it difficult to establish and grow at low temperatures, whereas, most of them grow normally under ambient conditions (Kader *et al.*, 1989). Thus more spoilage was noted in fruits stored at ambient temperature. The pear fruits harvested at optimum stage of maturity recorded the maximum palatability rating of 6.38 after 3 days at ambient temperature storage whereas the minimum palatability rating was observed in the fruits harvested at post-optimum stage of maturity. The weight of pear fruit decreased during storage and the fruits harvested late had higher organoleptic rating and it increased during storage (Bhat *et al*., 2012). However, keeping the pear fruits of even optimum maturity stage for more than 3 days at ambient temperature following the cold storage could not maintain the desirable quality traits.

CONCLUSION

Thus, it can be concluded from the above study that pear fruits harvested at optimum stage, can be stored for 60 days in cold storage (0-1^{0}C with 90-95% RH). The shelf life studies showed that fruits harvested at optimum stage of maturity retains maximum edible quality up to 3 days at ambient conditions (30.5 $\pm$ 2.5^{o}C and 80 $\pm$ 2.5 % RH).

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