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A review of management of pre and post-harvest factors affecting plum fruit quality

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Abstract

Plums are rich in nutritional value with ability to improve digestion of consumers. It is the dire need to keep this natural product in high quality availability to consumers for longer time. Many factors starting before harvest leading to storage influence the shelf life and quality of these nutritious products. Plum fruit quality can be maintained by applying different synthetic, biochemicals and/or natural products at the result-oriented timing. Storage conditions are also crucial in maintaining better shelf life and consumer acceptance. For this purpose, it is highly needed to understand and manage the factors influencing plum fruit quality. This review has been presented to assemble the scientific data regarding management of factors affecting the quality of plums before and after harvest.

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Introduction

Plums are the member of the Rosaceae family. They are consumed dried as well as fresh (Bozhkova, 2014). Two important species include European species (*Prunus domestica* L.), and Japanese species (*Prunus salicina* Lindell). *Prunus domestica* are eaten both fresh and dried, while the Japanese species (*Prunus salicina* Lindell), are liked fresh by the consumers (Manganaris *et al.,* 2008).

They are considered similar to nectarines and peaches in relation to nutrient and caloric content. Furthermore, they are consumed dried as well as fresh (Bozhkova, 2014). Plums are considered climacteric (i.e. fruits exhibiting abrupt rise in respiration just prior to completion of ripening coupled by ethylene production), although some plum cultivars remain behind schedule in boost in ethylene production and respiration waiting late ripening. Such cultivars act in response to exogenous ethylene, which is an important ripening regulator. (Sudheera and Indira, 2007; Manganaris *et al.,* 2008).

In this review, we will talk about the factors that act on plum fruit quality before harvest and after harvest. Moreover, we will discuss the treatments which can be used to keep the standards up to the mark.

Pre-harvest factors and treatments affecting plum fruit quality

It is important to keep the fruit quality at the standards of retailer and consumer to get lucrative marketing within export consignments of plums (Manganaris *et al.,* 2008). To keep the high standard quality, plums are to be dealt carefully from orchard till the consumer hand.

Canopy light condition influences fruit quality

Because of the light environment plum fruits ripen in descending order on trees. Thus, fruits on the lower part of tree remain small in size matures 10-14 days later than fruits on the upper part of trees. In addition, fruits on all plum plant postures need enough light for timely ripening and quality growth (Manganaris *et al.,* 2008).

Impact of titanium treatment

Better increased fruit size, fruit firmness retention, reduced weight loss during storage and superior fruit surface colour has been attained by titanium treatments. All these healthier attributes have been gained due to improved Ca, Fe, Zn and Cu uptake incited by Titanium (Alcaraz-Lopez *et al,*.2003; Manganaris *et al.,* 2008). Titanium has also been assessed in combination with Calcium, Magnesium and algae extract and showed good results (Alcaraz-Lopez *et al.,* 2004).

Soil management

Soil management influences secondary fruit metabolites accumulation. It has been observed that the ground covered or animal manure treated soil add more tocopherol, b-carotene, anthocyanin and total phenolic compounds in Plums than fruits grown on uncovered soil. (Manganaris *et al.,* 2008; Cuevas *et al.,* 2015). Chocano *et al.,* 2016 found that managing soil with compost had given better yield and quality of plum fruits. Furthermore, the soil quality in terms of carbon content and microbial pool has increased.

Application of growth regulators

Synthetic auxins can be applied at the start of pit-hardening in order to stimulate fruit cell extension, fruit size and production enhancement (Manganaris *et al.,* 2008; Stern *et al.,* 2007). Application of Gibbrelic acid (GA_3) has shown enhancement of tree growth and fruit yield (Suman *et al.,* 2017).

Post-harvest treatments and handling of plum fruit for better quality

Plum fruit harvesting is indicated by skincolor changes, lower TA, higher SSC and fruit firmness (Manganaris *et al.,* 2008; Usenik *et al.,* 2008). Application of ClO_2, Ultrasounds (Chen and Zhu, 2011), 1-methylcyclopropene (1-MCP) (Valero *et al.,* 2003), and exposure to super atmospheric oxygen (Kader and Ben-Yehoshua, 2000) can be used on plum fruit to enhance shelf life and fruit quality. Plums are often handpicked into bags. For transportation they are put into basket and send to packinghouse (Manganaris *et al.,* 2008).

Handling

It is suggested to avoid fruit from keeping in the fields for longer time. Softening of fruit can be prevented by immediate cooling of the fruits. Forced-air cooling or hydro cooling are Pre-cooling methods suggested for fast removal of field heat. (Manganaris *et al.,* 2008).

Grading and packaging

At the packinghouse, plums arewashed and sorted to eliminate visually defected fruits and to choose good color plums. Sizing is done by using grading gauges to separate fruit by both weight and/oraspect. (Crisosto and Kader, 2000; El-Ramady *et al.,* 2015).

Storage

Enhancement of shelf life of perishable foods is done by storing them at low temperature and controlled humidity level. This is done to prevent deterioration of fruits due to enzymatic activities. It is found that storage temperature and time of storage affects plum fruit sugar and organic acid levels (Zora and Khan, 2010).

Low temperature storage: Chilling coupled with appropriate controlled relative humidity (RH) is the most widely used techniques to lengthen the shelf-life of fruits. Over ripeness of plum fruit is inhibited at low temperature storage (Taylor *et al.,* 1993). Plums are chilling-sensitive. Fruits survive in market for 1 to 6 weeks. This span depends on the cultivar and the post-harvest management. Conditions of -1.1–0 °C temperature and 90–95% relative air humidity are recommended for plum storage (Manganaris *et al.,* 2008). Furthermore, keeping the fruits in polythene bags reduces skin shriveling (Plich, 1997).

Fruits treated with Putrescine (PUT) and stored at 0 ± 1 °C; 90 ± 5% RH showed higher fruit firmness (Khan *et al.,* 2008). Chitosan treatment proved effective to enhance postharvest life in plums (Bal, 2018). A delay in flesh breakdown development has been obtained by keeping vulnerable cultivars to flesh browning at -1.1°C. However, to store plums at such a reduced temperature, high SSC and accurate temperature control are essential to evade freezing damage (Manganaris *et al.,* 2008).

Controlled and modified atmospheres: Controlled atmosphere (CA) and Modified atmosphere (MA) storage have been revealed as an efficient tool in maintaining quality of many commodities. It is also important to assess the best method among CA and MA in terms of better storage and affordability of making and maintenance of the storages. Major benefits of CA for plum storage and shipment (1–2% O_2+3–5% CO_2) include delay of ground shade shifts, preservation of fruit firmness and lesser decay frequency. (Manganaris *et al.,* 2008). 0–5°C with 0–5% CO_2 and 1–2% O_2 has been recorded to have a superior storage effect. At 1°C with 12% CO_2 and 2% $O_2$with storage of 4 weeks has provided with a fine appearance, flavor and firmness. Moreover, in storage no CO_2 injury has been observed at concentrations below 16% −0.5°C with 0–5% CO_2 and 2% O_2(Thompson, 2003; Thompson, 2010).

Heat treatment in storage: Post harvest heat treatment sometimes delays ripening and sometimes it disrupts the ripening it happens according to the heat given, time for which fruit is heat treated and the immediate cooling of the fruits. Thus, wise heat treatment is required for fruitful results (Paull and Chen, 2000). Heat treatment at 45°C for 10 min improved plum fruit firmness and made cell wall more stable. It trimmed the physiological changes incited by mechanical damage in plum and also cut down the boost in ethylene manufacture incurred by wound and respiration pace. (Valero *et al.,* 2002; Manganaris *et al.,* 2008).

Disorders and diseases

Chilling injury

Development of physiological changes in fruits stored at low temperature leading to visibility of characteristic symptoms is termed as Chilling Injury (CI) (Wang, 1990). Due to chilling injury plum fruit flesh becomes translucent accompanied by flesh browning and lack of juiciness. By and large CI symptoms emergeby placing fruit at ripening temperature (20 °C) following cold storage at 2-8 °C due to high ethylene production (Manganaris *et al.,* 2008; Candan *et al.,* 2011). 1-MCP (1-methylcyclopropene) has been evaluated by scientist as a useful chemical to prevent Chilling injury by reducing ethylene (Dong *et al.,* 2002; Manganaris *et al.,* 2008; Velardo-Micharet *et al.,* 2017). Sharma and Sharma, 2015 assessed Sodium nitroprusside (SNP) treatment (source of nitric oxide) as an effective tool to reduce Chilling injury by up to 71%.

Brown rot

Brown rot of stone fruits is caused by *Monilia fructicola*. Fruit cracks serve as the entry site of pathogens thus makes late season cultivars more susceptible to grow moldy. The infection starts as blossom blight (preharvest) and spread in post-harvest storage, transportation to markets. Brown rot may even affect during fruit processing or even the processed fruit (Hong *et al.,* 1998; Papavasileiou *et al.,* 2015). Symptoms of brown rot include blossom and twig blight leading to soft decay of fruits. Firstly, tan brown color appears on fruit which then turns into ash-grey brown color due to accumulation of fungal spores (Latorre *et al.,* 2014).

As post-harvest treatment immersing plums in hot water (60ºC for 60 sec.) is effective for controlling this disease (Karabulut *et al.,* 2010). Postharvest fungicide treatment is a promising approach to fence the decay. Cultural strategies reduce the spore inoculums in orchard. Removing the infected plant materials and pruning reduce the fungal overwintering which helps a lot in reducing infection in next season.

Pichia membranaefaciens, *Kloeckera apiculata* (Zhang *et al.,* 2017), *Aureobasidium pullulans* and*Rhodotorula phylloplana* (Janisiewicz*et al.,* 2014), *Bacillus subtilis* (Pusey and Wilson, 1984), *Bacillus amyloliquefaciens* CPA-8 (Gotor-Vila *et al.,* 2017) have been found effective as bio control agents to tackle brown rot of plum.

Gray mold

The infection causing fungus is *Botrytis cinerea*. It serves as an agent to cause blossom blight in plum trees. So, the infection agents go to harvested fruit from orchard and may develop infection later on (Fourie and Holz, 1995; Crisosto and Kader, 2000; Ferrada *et al.,* 2016). In general escaping mechanical injuries, satisfactory temperature management, and postharvest fungicides application are helpful control actions (Crisosto and Kader, 2000). Anilinopyrimidines pyrimethanil, cyprodinil and mepanipyrim, phenylpyrrol fludioxonil and hydroxyanilide fenhexamid serve as an effective reduced risk chemical control measures against gray mold (Rosslenbroich and Stuebler, 2000; Förster *et al.,* 2007; Usall *et al.,* 2015).

Aureobasidium pullulans PL5 and *Cryptococcus laurentii* reduced post-harvest infection of *Botrytis cinerea* in apple (Roberts, 1990; Zhang *et al.,* 2010). Volatiles of the rosemary and peppermint essential oils have been found limiting post-harvest Gray mold infection in grapes (Servili *et al.,* 2017). It is the need to determine the action and efficacy of these bio control agents upon Plum fruit against *Botrytis cinerea*.

Rhizopus soft rot

Rhizopus stolonifer, is the causal organism of Rhizopus soft rot. Soft rot appears at 20 to 25 °C in ripe or nearby ripe stone fruits (Crisosto and Kader, 2000). The fungus gets entry by mechanical or physical damage (Baggio *et al.,* 2016). Lowering down fruits temperature and storing them below 5°C is effective as physical control (Crisosto and Kader, 2000). Gum Arabic (GA) and essential oils from *Rosmarinus officinalis* L. (ROEO) and *Origanum vulgare* L. (OVEO) in combination (Andrade *et al.,* 2017) and *Copernicia cerifera* wax (carnauba wax) (Gonçalves *et al.,* 2010) were found efficient means to control postharvest *Rhizopus* soft rot and plum fruit traits.

Conclusion

In this review we have seen, there are natural chemicals, synthetic chemicals and biological products that have been assessed successfully by scientists to improve shelf life of this fragile fruit. Now this the dire need of time to develop controlled atmospheric storages. Natural products can be used safely for preservation without any residual effects. Moreover, further development and standardization of biological products is needed for their large scale usage in fruit preservation.

In addition, plums can be protected from diseases by preventing them from physical and/or mechanical injury in field and in storages. We can reduce the chance of injury not remove it completely. Thus, different natural and biological products can help us combat infections by pathogens taking entry from bruises.

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