EFFECT OF GRAFTING ON THE QUALITY AND APPERANCE OF EGGPLANT FRUIT

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Abstract

The quality of vegetables is defined as size, shape, color, freshness, texture, flavour and health promoting compound. Grafting is a method of propagation that a part of a plant (scion) is joined to another plant (rootstock) which is forced to develop a vascular connection and grow as a single plant. Vegetable grafting has been used for several reasons: improving plant growth and yield, increasing tolerance against biotic and abiotic stresses. Vegetables produced by grafting methods can influence fruit quality and appearance. Labour and technique essential for grafting process; the price of grafted seedling and automated grafting machines are the disadvantage of this method. In the current review, we focus on effects and mechanisms involved in grafting on tomato, eggplant and pepper fruit quality. Investigators have found contradictory results due to different production environments, types of rootstock/scion combinations.

Key words: grafting, fruit firmness, fruit quality

Introduction:

Vegetable grafting is an asexual plant propagation technique by connecting two plant part have been used in both *Solanaceae* family i.e. tomato (*Solanum lycopersicum* L.), eggplant (*Solanum melongena* L.) and pepper (*Capsicum annuum L.* L.) and *Cucurbitaceae* family i.e. watermelon (*Citrullus lanatus* (Thunb.), melon (*Cucumis melo* L.), cucumber (*Cucumis sativus* L.), pumpkin and bitter gourd (Bie et al. 2017). Grafts have been used to induce resistance against low and high temperatures, reduce uptake of persistent organic pollutants from agricultural soils, raise salt and flooding tolerance, and limit the negative effect of boron and copper toxicity (Mozafarian et al., 2019).

This technique increases the yield in pepper (9.2%), eggplant (27.7%) and tomato (5.4-80.3%); produces large size fruit; prolongs postharvest life. Consumer demand for high-quality vegetable products such as texture, flavour, size, shape, color and, freshness has increased. It has been reported that these factors can be affected by grafting and the type of rootstock used.

In Hungary, nearly all tomato and 75% of watermelon are grafted seedling. Around 50% of tomato seedling in Morocco and Netherland; and about 65% of eggplant produced in Japan have been used grafted technique (Kumar and Kumar, 2017).

Effect of grafting on the fruit appearance:

Fruit shape index (ratio of equatorial and longitudinal diameter) affected by grafting in tomato and eggplant. For instance, in tomato was significantly less than in the fruit of grafted plants (Turhan et al., 2011) or grafting eggplant onto *Solanum torvum* caused a longer fruit (Cassaniti et al., 2011). The pericarp thickness of pepper in the grafted plant was higher (5%) than in non- grafted one (Doñas Uclés et al., 2014).

Skin or flesh color of fruit can influence by grafting and different rootstocks. Moncada et al. (2013) indicated that grafting eggplant onto *Solanum torvum* resulted in a darker and less vivid color. In tomato the skin color of fruit (a*) was lower during grafting compared to control (Ulukapi and Onus, 2005).

Fruit texture described as firmness related to calcium concentration, water relation, wax layer and transpiration of fruit. Grafting and rootstock can influence fruit firmness. Grafting by eggplant caused a reduction (- 13%) in fruit firmness (Cassaniti et al., 2011). In tomato, Khah (et al., 2006) reported that grafting had no influence on fruit firmness; even rootstock increased Ca concentration.

Effect of grafting on fruit quality:

Important quality parameter (good taste and flavor) related to the sugar and acid content of the fruit can be influenced by grafting and different rootstocks. Some researchers explained that grafting caused lower plant growth and fruit water content and resulted in higher SSC in tomato (Ntatsi et al., 2014; Rahmatian et al., 2014). While Kumar et al. (2015) and Riga (2015) reported sugar reduction in fruit due to increasing fruit water content.

Some researchers have described that sugar content of pepper, tomato, and eggplant don't affect by grafting (Colla et al., 2008; Turhan et al., 2011; Nicoletto et al., 2013; Lopez-Marin et al., 2013). Lower pH and TSS was observed in eggplant when grafted onto *Solanum torvum* (Khah, 2011).

Lycopene concentration of tomato decreased in grafted plants (Mohammed et al., 2009; Miskovic et al., 2009) while Turhan et al., 2011 and Khah et al. (2006) reported no difference of lycopene in grafted and non-grafted fruits.

Vitamin C and firmness of eggplant fruit negatively affected by grafting on *Solanum torvum* and *Solanum sisymbriifolium* and sensory analysis showed sweetness, acceptance and, the hardness of non-grafted fruit higher than grafted ones (Arvanitoyannis et al., 2005).

Crop quality tests

Consumers evaluate the visual appearance and color first; then taste and aroma. In the laboratory, the appearance of the fruit determines as color and texture by the following methods:

Color

Color, gloss, and appearance attract consumers to purchase. Color can be measured by simple color chart, pigment extraction, and spectrophotometry and instrumental methods. Evaluation by human is easy, fast and cheap but affected by human error. Colorimetry instruments are less variable, but the equipment is expensive.

In eggplant late browning in pulp and glossy skin are important. The whitening index of eggplant pulp and skin color can be measured by scanning mode with a Commission Internationale de l'Eclairage (CIE). Color space may be divided into a three-dimensional (L, a and b) such that L (lightness; 0 black and 100 white); a (red to green) and b (blue to yellow). The CIE $L^*a^*b^*$ values of the pulp can be determined and the whiteness index (WI) is calculated by the following equation (Amanatidou et al., 2000):

$$WI=100-((100-L)^2+(a^2+b^2))^{0.5}$$

Also, the oxidation potential of eggplant pulp can measure by CIE $L^*a^*b^*$ values at time 0 and 30.

$$CD= [(L^*_{30} - L^*_0) + (a^*_{30} - a^*_0) + (b^*_{30} - b^*_0)$$

Fruit pigments may also be analyzed by extraction, based on spectrophotometry.

Texture

After visual appearance, the texture of fruit is the most important factor for consumer and because of indirect measurement of ripeness for growers as harvest time and postharvest. It can measure by instrumental or sensory methods (destructive or non-destructive). Fruit firmness can evaluate easily by hand operated or electric penetrometer through universal testing equipped with a plunger (Riccardo N. Barbagallo et al., 2012). This method has some problems: measurements on the same sample may present huge variations because it tests only one side of the fruit at a time whereas the ripening process is not even; it is a destructive method, therefore, it is not suitable for packing (Macrelli et al., 2013).

Another equipment that can be used for firmness is texture analyser. Flat plate is a technique very similar to puncture and it can be both destructive and non-destructive way. Barrett et al. (1998) described another force measuring methods such as standard shear-compression cell (or Shear Press) and the back-extrusion cell.

A Non-destructive method (the force–deformation curve, the acoustic and impact response, ultrasonic methods), an optical property (visual methods, near-infrared spectroscopy), an electromagnetic property (nuclear magnetic resonance) or a chemical property (electronic nose) can be evaluated for fruit texture. Many researchers reported the relation between acoustic and mechanical properties of fruit and vegetables. In acoustic method, using vibrational responses in the frequency range from 20–10,000 Hz it was deemed possible to separate fruit by maturity and textural properties. Currently, this kind of methods are for laboratory trials, not always low cost, and rapid but later can adapt for packing company.

Sensory test

Fruit taste, aroma, and appearance can be evaluated by a trained sensory panel. For instance, Arvanitoyannis et al. (2005) evaluated the sensory test of grafted eggplant for 10 days in two temperatures. Small pieces of the fruit were boiled and were immediately assessed for sweetness, intensity, color, odour, tartness and non-boiled assed for appearance. Also, it can measure by instrumental methods (pH, Brix). Total soluble solids (TSS) as Brix and pH determine by the juice of fruit flesh onto a digital refractometer or pH meter.

Conclusion

Vegetable quality depends on cultivation, climate and genetic; and grafting as one propagation method can be a good environmentally friendly technique for increasing the quality and quantity of crop productions. There are many conflicting results of grafting effect on fruit quality due to different production environments, type of rootstock/scion combination used, and harvest date. For example, firmness was not affected by grafting in tomato or negative effect on eggplant when grafted on *Solanum torvum*. The same combination (eggplant on to *Solanum torvum*) caused a reduction of TSS. While other authors found that grafting for some scion- rootstock combination can increase TA (grafting tomato on to scarlet aborigine rootstock). In pepper, Colla et al. (2008) reported no difference in TA when grafted on to five commercial rootstocks.

Moreover, the rootstock-scion combination is an important role in fruit quality. For instance, eggplant rootstock (cv. *Madonna*) increased lycopene in tomato but other rootstocks investigated in Miskovic et al. (2008) experiment decreased the amount of this carotenoid.

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