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ROOTSTOCK MEDIATED EFFECT ON FRUIT RIPENING BEHAVIOUR AND PHYTOCHEMICAL COMPOSITION: AN OVERVIEW

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ABSTRACT

Rootstock plays an important role in propagating fruit trees and is being used in fruit production for more than 200 years. Yield, market value and fruit quality depend on grower's decisions on cultivation and harvesting practices, one of such factor is selection of rootstock, which mediates not only ripening behaviour, but also phytochemical composition of fruit. Fruit ripening behaviour is the series of physiological and biochemical events, exhibited by the fruit during its ripening process. Earliness and delay in ripening, ripening rate, fruit colour, firmness, chemical constituents and postharvest shelf life are the result of ripening behaviour and in turn affect the phytochemical composition of fruit as well. Rootstock mediates its role through absorption of water, nutrient and mineral translocation, source-sink rate, hydraulic and stomatal conductivity, dwarfness, photosynthesis, regulation and signalling of plant growth hormones, mRNA, gene expression, and phloem proteins transport. This impact on fruit ripening and composition occurs in both positive and negative way. Any rootstock species found to be the best choice for a particular scion cultivar, however, showed worst choice for another cultivar. Rootstock selection affects fruit quality attributes and thereby consumer liking and acceptance. It also serve as a method of enhancing phytochemicals, nutritional security and enhanced quality of postharvest products. Knowledge of rootstock mediated effect on fruit ripening and phytochemical composition can play a major role to evolve rootstock-scion combinations for enhanced postharvest quality of fruits.

Keywords:
Rootstock, Fruit, Influence, Postharvest quality

Introduction

Rootstock and Phytochemicals

Ripening behaviour is series of physiological and biochemical events, exhibited by the fruit during its ripening process. Early and delayed ripening, change in fruit colour, firmness, chemical constituents and their effect on postharvest shelf life, are the results of ripening behaviour of fruit. Thus, as ripening behaviour plays an important role in defining the concentration of phytochemicals (Hajagos *et al.*, 2012). The produced phytochemicals are the chemical compounds that occur naturally in plants (Phyto means

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"plant" in Greek) and have non-nutritive, disease preventive or protective properties. Eg: carotenoids, flavonoids, phenolic compounds, antioxidants, organic acids etc (Massimilianoet *al*., 2016; Yang *et al.*, 2015). Phytochemicals in fruit are useful to plants as they are involved in developing resistance and in various biochemical processes of the plant, whereas when they took up by the animals serve as nutraceuticals (Aviles *et al.*, 2010; Betemps *et al.*, 2015).

All these internal characteristics mentioned above along with yield, market value and fruit quality depend on grower's decisions on cultivation and harvesting practices such as selection of rootstock. The rootstock is the trunk or root material onto which buds or scions are inserted for budding or grafting. Various rootstocks in fruit crop reported to mediates not only ripening behaviour, but also phytochemical composition of fruit. Fruit ripening behaviour such as an earliness and delay in ripening, ripening rate, fruit colour, firmness, chemical constituents and postharvest shelf life are the result of ripening behaviour and in turn affect the phytochemical composition of fruit as well.

Rootstock affecting ripening behaviour and fruit quality

Postharvest quality and consumer appeal is must for the successful trade of fruits (Prasad and Sharma, 2016), the desire of postharvest quality of grower can be completed by selection and screening of cultivars which are high in cosmetic appeal and free from disorders affecting fruit quality, otherwise they have to depend on postharvest treatments to maintain postharvest quality. Betemps *et al.*, 2015; Prasad et al., 2016a: Prasad et al., 2016b). Rootstock affect ripening behaviour by the various means of altering the mechanisms of early maturity and ripening , late maturity and ripening, physical characteristics during ripening (size of fruit, peel thickness, peel colour), physiological processes during ripening (ethylene, respiration), altering fruit phytochemicals and composition and enhancing or delaying postharvest shelf life (Aviles *et al.*, 2010;Hajagos *et al.*, 2012).

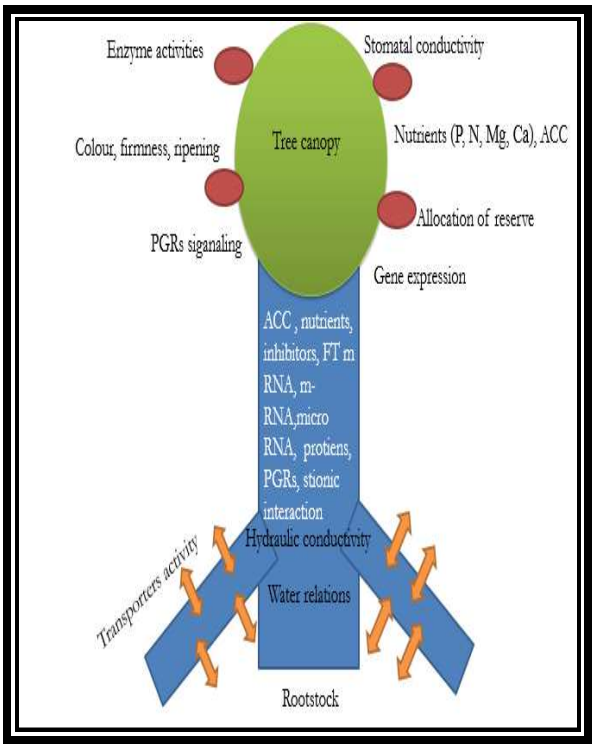

Fig: Effect of rootstock on fruit quality.

The changes are related to change in biochemical composition, root conduction, stomatal conductivity, RNA moment across the stion, auxin and plant growth regulators signalling, gene expression. These are the factors along with environmental and plant framework factor, affects the stionic behaviour and regulation on fruit ripening. Market driven production, external appearance, returns to the growers (colour, texture), health benefit, postharvest quality (eg- wine raisins, juices) and shelf life along with the development of flavour and volatiles are the key possible benefits which humans can explore from rootstock mediated effect on fruit ripening and biochemical composition (Hajagos *et al.*, 2012; Massimilianoet *al*., 2016; Yang *et al.*, 2015).

Examples of rootstock mediated ripening behaviour and change in the phytochemicals in fruit crops.

Pear

Table 1. Rootstock mediated effect on 'Conference' pear as reported by Kviklys and Kvikliene (2004).	
Rootstock	**Effect on fruit**
Quince MA	Delayed ripening. Increased TSS
Quince MC	Early crop, high yield
Sydo	Early crop, Low TSS
BA29	No significant effect
S1	Low TSS
Pyrus × communis seedling	Firmer at harvest
K11	Early crop, increased TSS
K16	Late ripening, softer fruits at harvest
1.2	Decreased yield, high TSS

Peach

Table 2. Effect on 'Flavocrest' Peach ripening and phytochemical composition as reported by Remorini *et al*., 2008.	
Rootstock	**Effect on phytochemicals**
GF 677	H1: Increased total phenol content
	H2: decreased β carotene
	H3: No significant effect
Barrier 1	H1: Increased phenol
	H2: No significant effect
	H3: Increased β carotene
Ishtara	H1: Decreased total acid, increased phenol content
	H2: No significant effect
	H3: Increased fruit colour and β carotene
Mr S 2/5	H1: Increased total phenol
	H2: No significant effect
	H3: Increased SSC, fruit colour, TAC, Vit. C and β carotene

Cherry

Table 3. Rootstock mediated effect on cherry as reported by Hajagos *et al*., 2012		
Name of the root stock	Scion	Effect on ripening behaviour
GiSelA 5	Regina	No significant effect
GiSelA 6	Regina	Increased fruit firmness and taste
Piku- 1	Regina	increased taste
PHL-C	Regina	No significant effect
Weiroot 158	Regina	Increased fruit firmness and taste
GiSelA 5	Kordia	No significant effect
GiSelA 6	Kordia	No significant effect
PHL-C	Kordia	No significant effect
Weiroot 158	Kordia	No significant effect

Grapes

Massimiliano *et al.*, 2016 reported in grapes that Grapevine Rootstocks differentially affected the rate of ripening and modulated auxin-related Genes in Cabernet Sauvignon berries. The change in skin pigmentation was paralleled by changes in the transcript accumulation of flavonoid biosynthesis (phenylalanine ammonia lyase, VviPAL3-like; chalcone synthase 3, VviCHS3; flavanol synthase 1, VviFLS1; leucoanthocyanidin reductase 1 and 2, VviLAR1 and VviLAR2), flavone- and flavonol- (VviUFGT) related genes. In particular, the expression of VviPAL3-like, VviCHS3, VviLAR2, and VviUFGT occurred earlier (E-L36 M4) and was higher in CS/M4 berries than in CS/1103P ones. The PCA analysis revealed that the early pre-veraison stage (45 DAFB) was strictly associated with the accumulation of VviGH3-22 transcripts, whereas the induction of other genes, such as VviLAR2, VviGH3-23, and VviGH3-17, marked the late pre-veraison stage (68 DAFB) in both graft combinations. At 72 DAFB, by the time CS/M4 berries almost completed the change of skin colour (accompanied by the induction of VviCHS3 and VviUFGT transcription), CS/1103P was still in pre-veraison

stage and reached mid/late veraison (marked by the accumulation of IAA-asp and flavonoids) at 86 DAFB. Further, Massimilianoconcluded that the pre-veraison stages (E-L31-34) were similar to berries are grown in both graft combinations, for SSC and CIRG. The ripening rate was different. Based on CIRG index values, the pigmentation of berry skin in CS/1103P displayed a 14-days delay compared to CS/M4 and The rate of berries ripening in CS plants grafted onto M4 is faster (in terms of change of skin colour and sugar accumulation) than that observed in the CS/1103P combination

Mandarin

Legua*et al.*, 2014 reported that total phenolics, organic acids, sugars and antioxidant activity of mandarin (*Citrus clementina* Hort. ex Tan.) were affected from therootstock. When mandarin grafted with selected rootstocks the results were surprising as ripening index was highest in Forner alkcaide 13,similarly,major organic acids and total phenolics was found highest in rootstock volkameriana, whereas, major sugars was found highest in rootstock Cleopatra mandarin. Legua*et al.*, 2014 concluded that the significant variation in total phenolics organic acids, antioxidant activity and sugars composition related to water relations and genetic factor associated with the rootstock .and rootstock plays an important role in determining the concentration of bioactive compounds and in turn organoleptic, nutritive, and sensory property of juice as well.

Conclusion

There is the effect of rootstock on ripening behaviour and phytochemical composition, which is decided by the combination of rootstock and scion. Any rootstock species found to be the best choice for a particular scion cultivar, however, showed worst choice for another cultivar. There is a lot of scope in this field, to explore rootstock-scion combinations for obtaining an enhanced level of bio actives.Thus knowledge of rootstock mediated effect on fruit ripening and phytochemical composition can play a major role to evolve rootstock-scion combinations for better quality of fruits.

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