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Effect of pre-harvest calcium treatments on loquat fruit (*Eriobotrya japonica* cv. Algerie) firmness

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SUMMARY – Loquat fruit is especially susceptible to bruising since harvest is done after fruit matures in the tree. Fruit firmness decreases with ripening, the handling during harvest, packaging and storage being a critical point in the final fruit quality. Therefore, the higher the fruit firmness at harvest the lower the risk of fruit quality loss due to bruising. Calcium treatments have been shown to improve fruit firmness in apple, apricot, pear and peach, all of them belonging to the Rosaceae family like loquat. In this work we have tested in the field pre-harvest applications of foliar spray of different calcium-containing solutions of calcium chlorine and calcium chelate in order to determine its effect on fruit firmness in a standard material test. We have compared the effect of treatments in unprotected and in mesh-protected orchards. In both types of orchards, calcium treatments increased fruit firmness up to 20%. The levels of firmness increase are comparable to those reported for other fruits of the Rosaceae family.

Key words: Polyphenol oxidase, enzymatic browning, phenolics, loquat.

RESUME – *"Effet des traitements à base de calcium avant la récolte sur la fermeté des néfles (*Eriobotrya japonica *cv. Algérie)". La nèfle est particulièrement susceptible aux meurtrissures dès le moment de la récolte. Elle se cueille une fois le fruit mûr sur l'arbre. La fermeté du fruit diminue avec la maturité ce qui rend la manipulation pendant la récolte, en l'empaquetant et en la stockant, un point critique pour la qualité finale du produit. Par conséquence, plus le fruit est ferme pendant la récolte, moins on court le risque de perdre la qualité du fruit à cause des meurtrissures (ou des coups). Les traitements à base de calcium ont été utilisés pour améliorer la fermeté du fruit sur la pomme, l'abricot, la poire et la pêche lesquels appartiennent tous à la famille des Rosaceae comme la nèfle. Dans ce travail, nous avons essayé dans le champ avant la récolte l'application de solutions qui contiennent du calcium, du chlorure de calcium et du chélate de calcium dans le but de determiner leur effet sur la fermeté du fruit dans un test matériel standard. Nous avons comparé l'effet des traitements dans des parcelles non protégées et sous mailles. Dans les deux genres de parcelle, les traitements à base de calcium augmentèrent la fermeté du fruit de 20%. Les degrés de fermeté augmentés sont comparables à ceux présentés dans d'autres fruits de la famille des Rosaceae.*

Mots-clés : *Polyphénoloxydase, noircissure enzymatique, phénoliques, nèfle.*

Introduction

The bruising of ripe fruits is a consequence of the enzymatic browning that occurs in damaged tissues (Mayer and Harel, 1979). Loquat fruit is especially susceptible to bruising since harvest is done after this kind of fruit matures in the tree, when polyphenol oxidase and phenolics reach the highest levels. A good fruit firmness at the moment of harvest reduces the incidence of bruising since the fruit is more resistant to mechanical damage. The fruit firmness decreases with ripening making the handling during harvest, packaging and storage a critical point in the final fruit quality. Therefore, the highest the fruit firmness at harvest the lower the risk of fruit quality loss due to bruising. Calcium has a major role in preservation of integrity of biological membranes and plant cell walls. Due to its low mobility, fast growing tissues such as fruits, may be calcium-deficient, thus, giving rise to physiological disorders (Bangerth, 1979), which are associated to loss of firmness. Application of calcium salts as spray has been used as a way to increase the content of this element in the fruit. Calcium treatments have been shown to improve fruit firmness in apple (Siddiqui and Bangerth, 1995), apricot (Tzoutzoukou and Bouranis, 1997) and pear (Raese *et al.,* 1999), which belong to the Rosaceae family like loquat.

In this work we have tested in-field pre-harvest application of foliar spray of different calcium-containing solutions of calcium chlorine and calcium chelate in order to determine its effect on loquat

fruit firmness in a standard material test. We have compared the effect of treatments in unprotected and in mesh-protected orchards.

Materials and methods

Experimental design

For each treatment, three sets of five trees randomly distributed in the experimental orchards of Cooperativa Agrícola de Callosa d'En Sarriá (Alicante) were established. Treatments were applied as a solution sprayed on the tree (5 to 6 litres/tree per application). The schedule of treatments' application is given in Table 1.

Table 1. Treatments and application schedule

Treatment	Date				
	24/01	21/02	14/03	28/03	04/04
Control (unprotected conditions)					
$CaCl_2$ 40 meq/l	●	●	●	●	●
$CaCl_2$ 80 meq/l	●	●	●	●	●
$CaCl_2$ 160 meq/l	●	●	●	●	●
$CaCl_2$ 160 meq/l				●	●
Ca quelate 40 meq/l	●	●	●	●	●
Ca quelate 80 meq/l	●	●	●	●	●
Boric acid 0.025%		●	●	●	●
Boric acid 0.05%		●	●	●	●
Tetraborate 0.0205% (eqv. 0.025%)		●	●	●	●
$CaCl_2$ 160 meq/l – Boric acid 0.025%				●	●
Control (mesh-protected)					
$CaCl_2$ 80 meq/l (mesh-protected)	●	●	●	●	●
$CaCl_2$ 160 meq/l (mesh-protected)				●	●
Ca quelate 80 meq/l (mesh-protected)	●	●	●	●	●

Texture assay

Loquat fruits were sampled twice during the harvest time: first, two weeks after last treatment, and second, three weeks after last treatment. Loquat samples were immediately assayed for firmness in a texturometer fixed with a 2 cm Ø cylindrical probe. Fruit is pressed at a rate of 2 cm/min and firmness is determined from the slope of the linear part of the force-distance plot. Each datum is the average of at least 20 texture determinations. Significance of texture differences between treatments was analyzed by an ANOVA test.

Results and discussion

Table 2 shows the comparison of firmness between controls of open-field and mesh-protected crops. Under the mesh there were three sectors that were checked independently: only mesh-protected, mesh-protected plus a refrigerating water spray and mesh-protected plus microspray. As can be seen in this Table, trees grown under the mesh produce fruits that are as firm as their open-field counterparts (first sampling 18/04) or a bit softer (sampling 24/04). However, those fruits grown under the mesh equipped with refrigerating sprays or microsprays are significantly softer than the no-refrigerated counterpart.

Figures 1 and 2 show the effect of foliar spray treatments on the firmness of loquat grown in open-field. Data correspond to loquats sampled two weeks (Fig. 1) and three weeks (Fig. 2) from the last treatment date.

Table 2. Comparison of firmness between open-field and mesh protected loquat crops[†]

Controls	Firmness (kg/cm^3)	Standard deviation
18/04 unprotected	2.28 a1	0.23
24/04 unprotected	2.35 a2	0.27
18/04 mesh-protected	2.25 a1	0.39
24/04 mesh-protected	2.11 b2	0.23
18/04 mesh-protected with spray	2.02 b1	0.20
18/04 mesh-protected with microspray	2.05 b1	0.28

[†]There are two significance groups at 95% confidence (a and b) for each sampling (1 and 2).

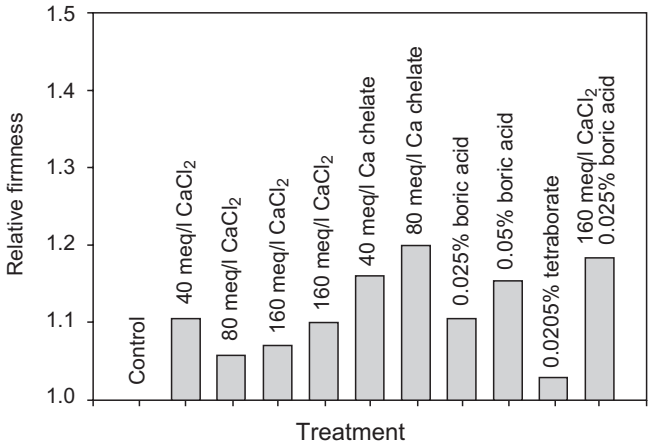

Fig. 1. Effect of foliar spray treatments on the firmness of loquat grown in open-field. Sampling two weeks after end of treatments (18/04/01).

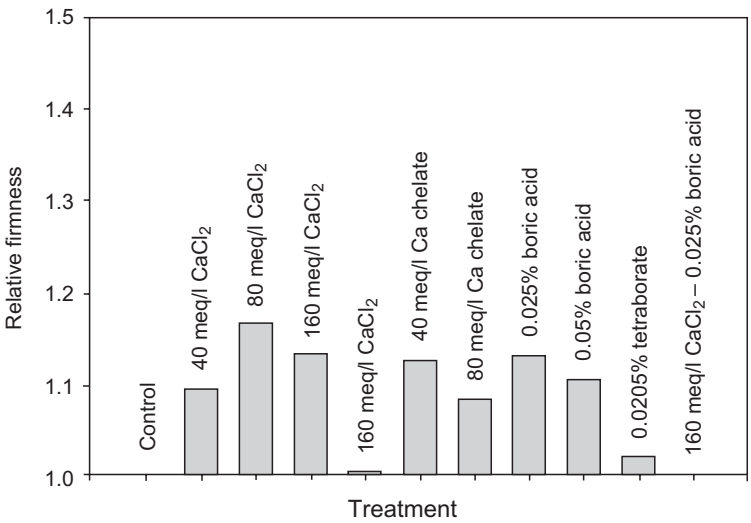

Fig. 2. Effect of foliar spray treatments on the firmness of loquat grown in open-field. Sampling three weeks after end of treatments (24/04/01).

All treatments with the exception of tetraborate were successful to increase the firmness of loquat, ranging from 5 to 20% of improvement. Calcium chlorine applied at high dose two and three weeks before first sampling was shown to be more effective than applied in prolonged treatments. Calcium chelate was more effective that calcium chlorine. Boric acid exhibited an intermediate affectivity between calcium chelate and chlorine. The combined treatment of boric acid and calcium chlorine – high dose – displayed an accumulated effect of those independent treatments.

Figure 3 shows the effect of foliar spray treatments on the firmness of loquat grown under a protecting mesh, that may have refrigerating spray or microspray devices. Data correspond to loquats sampled two weeks from the last treatment date.

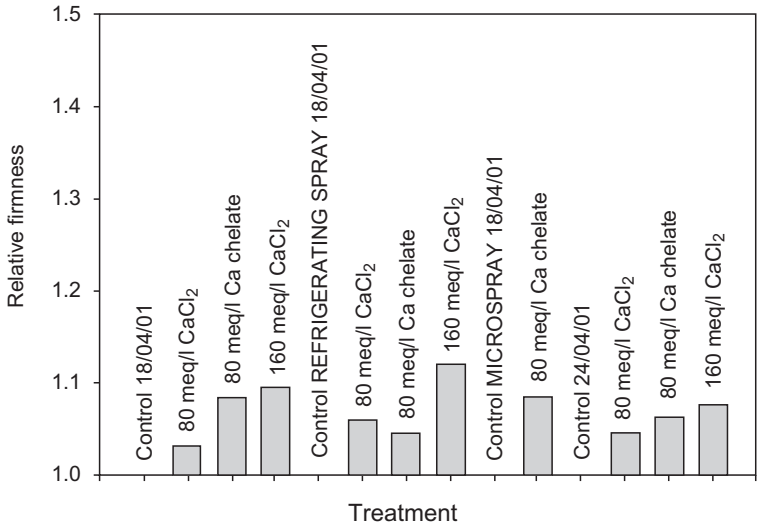

Fig. 3. Effect of foliar spray treatments on the firmness of loquat grown under a protecting mesh, that may have refrigerating spray or microspray devices. Sampling time is indicated in the graph.

The effect of prolonged treatments holds three week after the end of applications but the effect of short treatments completely disappears. See for instance the treatment with 160 meq/l calcium chlorine applied twice and five-fold. Loquats treated with calcium chlorine retain or even improve their firmness with respect to the controls while those treated with chelate or boric acid reduce their difference in firmness with respect to controls.

Although loquats grown under the mesh with refrigerating devices are softer, calcium treatments acted similarly on all cropping conditions (only mesh, with spray and with microspray), that is, firmness increased significantly between 5 and 12% depending on the treatment. A short treatment with a high dose of calcium chlorine was the more effective, and held its effect even three weeks after end of treatments. At the same dose and application frequency, calcium chelate was more effective than calcium chlorine. Calcium is an important element in the composition of the plant cell wall contributing to form ionic links between negatively charged polysaccharides, particularly the pectin fraction. Boron is also an important element that serves to crosslink certain components of the pectin fraction of the cell wall (Carpita and McCann, 2000). The pectin fraction is believed to be the most important cell wall component to impart firmness to the plant tissue, in particular when pectins form a tight polymeric network. Thus, both elements, Ca and B, were applied in different chemical forms as foliar spraying to loquat trees with the aim of improve the fruit firmness. Calcium has been described to improve firmness in other rosaceae tree fruits – peach, apricot, apple and pear – and so was with loquat. The degree of improvement is of the same order than that described for other rosaceae fruits. Boron has not been previously described as a firmness improver element. The results presented here clearly indicate that alone – in the form of boric acid but not tetraborate – or combined with calcium chlorine, boron produces a significant improvement of loquat flesh firmness. With respect to calcium, the chelate form appeared to be more effective than chlorine although the effect of calcium chlorine seems to hold better for longer term. A high dose of calcium chlorine applied in low frequency is effective in short term, but effectively disappears in longer term. More frequent treatments maintain their firmness improvement for longer term.

Conclusions

With the exception of tetraborate, foliar spray of calcium either chlorine or chelate, boric acid and a combination of calcium chlorine and boric acid, resulted in significant improvement of loquat firmness. The levels of firmness increased are comparable to those reported from other Rosaceae family fruits.

Although fruits grown in mesh protected orchard are significantly softer than those grown in unprotected-field, their firmness increased with three foliar sprays applied.

Short treatments (twice) improve firmness effectivity in short term while the effect of prolonged treatments (five times) remains for longer time on the fruits.

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