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*in*

Llácer G. (ed.), Badenes M.L. (ed.).
First international symposium on loquat

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 58

2003
pages 187-190

# A correlation study of loquat (*Eriobotrya japonica* cv. Algerie) fruit quality parameters: Flesh firmness and purple spotting

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**SUMMARY –** The quality of fresh fruits relies very much on its external appearance: size, colour and texture. In the case of loquat, large sizes are obtained by thinning practices, although large fruits are more susceptible of suffering the so-called "purple spotting" which is a partial decolouring of the fruit epidermis. Optimal fruits have a characteristic texture that becomes softer as the fruit ripens. Both, the purple spotting and the flesh firmness, affect very much the fruit quality as perceived by the consumer. Purple spotting is considered to be a physiopathy caused by local calcium deficit whereas there are no studies on the texture of the loquat fruit. Since both are important to fruit quality we have carried out a correlation study in which correlation coefficients for a set of selected variables are determined. In particular, our objective was to look for variables well correlated to loquat flesh firmness and purple spotting incidence at harvest. We found that firmness correlated with juice conductivity – mS/cm – (a=1.141, b=1.146, $r^2$=0.6239) and polyphenol oxidase – units/100 g fw – (a=-830, b=2363, $r^2$=0.4466) whilst purple spotting correlated well with pH – units – (a=-0.039, b=3.52, $r^2$=0.6084), acidity – % malic acid – (a=0.023, b=0.347, $r^2$=0.4889), Ca – mg/kg dw – (a=-350, b=9370, $r^2$=0.4694), Cu – mg/kg dw – (a=-0.61, b=8.33, $r^2$=0.5466) and Zn – mg/kg dw – (a=-1.04, b=26.64, $r^2$=0.5466).

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

***RESUME –*** *"Etude de corrélation des paramètres de qualité des néfles (*Eriobotrya japonica *cv. Algérie): Fermeté de la chair et tache violette". La qualité des fruits frais est mise en relation avec son apparence externe: taille, couleur et texture. Dans le cas de la nèfle, les gros calibres s'obtiennent par des pratiques d'éclaircissage de la fleur, bien que les gros fruits soient plus susceptibles de souffrir ce que nous appelons "la tache violette" qui consiste en une décoloration partielle de la peau du fruit. Les gros fruits ont une texture caractéristique qui devient plus douce au fur et à mesure que le fruit mûrit. La tache violette et la fermeté de la pulpe affectent beaucoup la qualité du fruit de la façon dont le consommateur la perçoit. On considère la tache violette comme une physiopathie causée par un déficit local de calcium alors qu'il n'existe pas d´études sur la texture de la nèfle. Comme tous deux sont importants pour la qualité du fruit, nous avons fait une étude de corrélation dans laquelle les coefficients de corrélation d'un ensemble de variables sélectionnées sont déterminés. En particulier, notre objectif était de chercher des variables bien corrélées avec la fermeté de la pulpe de la nèfle et l'incidence de la tache violette pendant la récolte. Nous trouvons que la fermeté est corrélée avec la conductivité du jus – mS/cm – (a=1.141, b=1.146, $r^2$=0.6239) et le polyphénol oxydase – unités/100 g fw – (a=-830, b=2363, $r^2$=0.4466) alors que la tache violette est bien corrélée avec les unités de pH – unités – (a=-0.039, b=3.52, $r^2$=0.6084), acidité – % acide malique – (a=0.023, b=0.347, $r^2$=0.4889), Ca – mg/kg fw – (a=-350, b=9370, $r^2$=0.4694), Cu – mg/kg fw – (a=-0.61, b=8.33, $r^2$=0.5466) et Zn – mg/kg fw – (a=-1.04, b=26.64, $r^2$=0.5466).*

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

## Introduction

The quality of fresh fruits very much relies on its external appearance: size, color and *texture*. In the case of loquat, large sizes are obtained by thinning practices (Agustí *et al*., 2000) although large fruits are more susceptible of suffering the so-called "purple spotting" which is a partial decoloring of the fruit epidermis. Optimal fruits have a characteristic texture that becomes softer as the fruit ripens. Both, the purple spotting and the flesh firmness, affect very much the fruit quality as perceived by the consumer. Purple spotting is considered to be a physiopathy caused by a local calcium deficit (Tuset *et al*., 1999) while there are no studies on the texture of the loquat fruit. Since both are important to fruit quality we have carried out a correlation study in which correlation coefficients for a set of

selected variables are determined. In particular, our objective was to seek for variables well correlated to loquat flesh firmness and purple spotting incidence at harvest. Two groups of variables were studied: fruit juice physical-chemical variables (pH, electrical conductivity, total sugars and titrable acidity) and fruit content in mineral nutrients (Na, K, Mg, Ca, Fe, Cu, Mn and Zn).

## Materials and methods

### Biological materials

Loquat fruits (*Eriobotrya japonica* cv. Algerie) from trees cropped in the experimental orchards of Cooperativa Agrícola de Callosa d'En Sarriá were picked ripe in April 2001. Fruits for determination of texture were kept fresh until the next day and then analyzed; those for determination of physical-chemical variables were kept at –20ºC until use; those for determination of nutrients were dessicated in a stove, pulverized in a blender and stored protected from humidity.

### Analytical procedures

For the determination of physical-chemical parameters, the loquat flesh was homogenized with water and filtered through eight layers of gauze. The filtrate was used for determination of pH, electrical conductivity, titrable acidity as % malic acid and total sugars by refractometry. For the determination of nutrients, samples of powdered loquat were mineralized by acid digestion and the elements Na, K, Mg, Ca, Fe, Cu, Mn and Zn were quantified by atomic absorption spectrometry (AAS). Loquat samples were assayed for firmness in a texturometer fixed with a 2 cm Ø cylindrical probe. Fruit is pressed at a rate of 1 cm/min and firmness is determined from the slope of the linear part of the force-distance graph. Each datum is the average of at least 20 texture determinations. Incidence of purple spotting was determined over the whole harvest of each plot as % kg affected.

### Experimental design

Sixteen plots randomly distributed in the experimental orchards of Cooperativa Agrícola de Callosa d'En Sarriá containing from 10 to 15 trees per plot were selected for loquat sampling. Three samples of each plot were taken independently from all trees for determination of all variables. Coefficients of linear regression and correlation coefficients at 95% confidence were determined crossing pairs of variables by LSD.

## Results and discussion

Table 1 shows the values of one set of variables analyzed for each of the sixteen plots sampled. The correlation analysis shown in Table 2 of loquat juice physical-chemical parameters and the fruit quality parameters flesh firmness and purple spotting occurrence reveal that firmness correlated only with juice conductivity – mS/cm – whilst purple spotting is related to pH, acidity and total calcium. The results shown in Table 3 indicate that a high concentration of ions in the juice is accompanied by an increase in the firmness of the fruit, and on the other hand, low incidence of purple spotting occurs in fruits whose pH is high, acidity is low and the content of calcium is high. Since calcium is distributed in soluble an insoluble fractions a deeper analysis of calcium fractions should indicate whether purple spot would be related to calcium fractions.

Table 4 shows the values of the other set of variables – content of mineral nutrients – analyzed for each of the sixteen plots sampled. The correlation analysis shown in Table 5 of loquat mineral nutrients content and the fruit quality parameters flesh firmness and purple spotting occurrence reveal that firmness does not correlate with particular elements nor with the sum of all of them – results not shown – whilst purple spotting correlates negatively with the micronutrients Zn and Cu in addition to the macronutrient Ca. The content of these three elements, Ca, Cu and Zn, correlated negatively with pH as well – results not shown – thus there may be an effect of pH on the uptake of these elements by the fruits. The results shown in Table 6 indicate that low incidence of purple spotting occurs in fruits

whose content in Ca, Zn and Cu is high. Bearing in mind that fruit juice pH has a minimum in the moment of colour break, and on the other hand that purple spotting becomes apparent just before colour break it could be speculated that a fruit juice pH too acid before fruit colour change may favor the development of purple spotting.

Table 1. Loquat juice physical-chemical variables

| Sample | Firmness ($kg/cm^2$) | Purple spot (% kg) | pH | Electrical conductivity (mS/cm) | Ca (g/kg dry weight) | Sugar (%) | Malic acid (%) |
|---|---|---|---|---|---|---|---|
| A1 | 2.28 | 5.69 | 3.37 | 3.63 | 8.74 | 4.70 | 0.39 |
| B1 | 2.28 | 0.50 | 3.55 | 3.81 | 10.55 | 5.20 | 0.36 |
| A2 | 2.52 | 1.16 | 3.49 | 3.93 | 9.76 | 4.30 | 0.38 |
| A3 | 2.41 | 0.84 | 3.44 | 4.04 | 7.95 | 4.40 | 0.46 |
| A4 | 2.44 | 1.68 | 3.39 | 3.92 | 7.09 | 4.70 | 0.40 |
| A5 | 2.51 | 5.08 | 3.36 | 4.11 | 8.27 | 4.50 | 0.45 |
| A6 | 2.65 | 0.11 | 3.46 | 4.09 | 9.45 | 4.10 | 0.36 |
| A7 | 2.74 | 0.61 | 3.58 | 4.13 | 9.61 | 4.50 | 0.31 |
| A8 | 2.53 | 1.31 | 3.43 | 4.20 | 9.76 | 5.10 | 0.42 |
| A9 | 2.63 | 7.68 | 3.13 | 4.43 | 6.85 | 4.70 | 0.66 |
| A10 | 2.34 | 1.38 | 3.47 | 3.93 | 8.34 | 3.70 | 0.35 |
| A11 | 2.69 | 4.81 | 3.52 | 4.06 | 7.52 | 4.80 | 0.36 |
| A12 | 2.33 | 4.79 | 3.33 | 3.63 | 6.77 | 5.30 | 0.46 |
| A13 | 2.47 | 6.36 | 3.20 | 4.02 | 6.69 | 4.30 | 0.50 |
| A14 | 2.25 | 3.41 | 3.28 | 3.63 | 7.20 | 4.90 | 0.43 |
| A15 | 2.44 | 3.61 | 3.39 | 3.86 | 8.11 | 5.00 | 0.42 |

Table 2. Correlation coefficients of physical-chemical variables and quality parameters

| Variable | Firm | pH | EC | Ca | Sugar | Malic | Spot |
|---|---|---|---|---|---|---|---|
| Firm | – | 0.0317 | 0.6239 | 0.0125 | 0.0554 | 0.000007 | 0.00007 |
| pH | | – | 0.0085 | 0.5401 | 0.0087 | 0.7819 | 0.6084 |
| EC | | | – | 0.0075 | 0.0889 | 0.1368 | 0.0023 |
| Ca | | | | – | 0.0456 | 0.3847 | 0.4694 |
| Sugar | | | | | – | 0.0260 | 0.0410 |
| Malic | | | | | | – | 0.4889 |
| Spot | | | | | | | – |

Table 3. Coefficients of linear regression: var1=a*var2+b

| Variable 1 | Variable 2 | a | b | $r^2$ |
|---|---|---|---|---|
| Firm | EC | 1.141 | 1.146 | 0.6239 |
| pH | Malic | -0.588 | 2.42 | 0.7819 |
| Spot | Malic | 0.023 | 0.347 | 0.4889 |
| Spot | pH | -0.039 | 3.52 | 0.6084 |
| Spot | Ca | -0.352 | 9.37 | 0.4694 |
| Malic | Ca | -14.68 | 14.31 | 0.3847 |
| pH | Ca | 7.46 | -17.08 | 0.5401 |

Table 4. Content in macro and microelements in loquat fruit (g/kg)

| Sample | Ca | Na | Mg | K | Fe | Cu | Mn | Zn |
|---|---|---|---|---|---|---|---|---|
| A1 | 8.74 | 8.32 | 2.46 | 9.85 | 0.18 | 0.0046 | 0.0022 | 0.0232 |
| B1 | 10.55 | 14.84 | 2.63 | 12.62 | 0.10 | 0.0077 | 0.0022 | 0.0232 |
| A2 | 9.76 | 4.83 | 2.36 | 13.17 | 0.07 | 0.0084 | 0.0022 | 0.0280 |
| A3 | 7.95 | 4.65 | 2.05 | 10.39 | 0.09 | 0.0092 | 0.0011 | 0.0285 |
| A4 | 7.08 | 3.50 | 1.72 | 10.55 | 0.09 | 0.0061 | 0.0011 | 0.0222 |
| A5 | 8.26 | 5.46 | 1.87 | 12.15 | 0.09 | 0.0077 | 0.0022 | 0.0227 |
| A6 | 9.44 | 7.11 | 1.66 | 13.33 | 0.07 | 0.0099 | 0.0016 | 0.0275 |
| A7 | 9.60 | 2.70 | 1.72 | 12.23 | 0.09 | 0.0092 | 0.0016 | 0.0280 |
| A8 | 9.76 | 6.10 | 1.46 | 15.16 | 0.04 | 0.0061 | 0.0005 | 0.0211 |
| A9 | 6.85 | 2.35 | 1.19 | 12.31 | 0.07 | 0.0038 | 0.0027 | 0.0180 |
| A10 | 8.34 | 2.22 | 1.42 | 13.25 | 0.07 | 0.0046 | 0.0060 | 0.0269 |
| A11 | 7.52 | 2.01 | 1.23 | 10.86 | 0.09 | 0.0046 | 0.0049 | 0.0211 |
| A12 | 6.77 | 1.97 | 1.17 | 11.61 | 0.08 | 0.0046 | 0.0060 | 0.0185 |
| A13 | 6.69 | 1.97 | 1.13 | 11.84 | 0.04 | 0.0046 | 0.0033 | 0.0211 |
| A14 | 7.20 | 2.30 | 1.27 | 10.47 | 0.07 | 0.0069 | 0.0049 | 0.0217 |
| A15 | 8.11 | 3.25 | 1.46 | 12.39 | 0.09 | 0.0054 | 0.0055 | 0.0238 |

Table 5. Correlation coefficientes of loquat elements and quality parameters

| Variable | Ca | Na | Mg | K | Fe | Cu | Mn | Zn |
|---|---|---|---|---|---|---|---|---|
| Firm | 0.0125 | 0.0848 | 0.0691 | 0.1009 | 0.0926 | 0.0553 | 0.0914 | 0.0186 |
| Spot | 0.4694 | 0.1346 | 0.1799 | 0.1273 | 0.0161 | 0.5466 | 0.1239 | 0.5466 |

Table 6. Coefficients of linear regression: var1=a*var2+b

| Variable 1 | Variable 2 | a (mg/kg UNI) | b (mg/kg) | $r^2$ |
|---|---|---|---|---|
| Spot | Ca | -350 | 9370 | 0.4694 |
| Spot | Zn | -1.04 | 26.64 | 0.5466 |
| Spot | Cu | -0.61 | 8.33 | 0.5466 |

## Conclusions

From this correlation study it can be concluded that loquat flesh firmness and purple spotting are statistically related to variables from the fruit juice and content in certain nutrients. This may serve as a guide to design treatments aimed at increasing firmness and reducing purple spot incidence.


### Acknowledgements

This work has been supported in part by grants DGESIC (AGF99-0396) and research contract between Universidad de Alicante and Cooperativa Agrícola de Callosa d'En Sarriá. Juan Casado Vela is holder of a grant provided for Spanish Science and Technology Ministry. We thank Pepi Fernández Sánchez and Isabelle Florit for their kind translation and language review.


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