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[1]Department of Citriculture, Murcian Institute of Agriculture and Food Research and Development (IMIDA), La Alberca, Murcia, Spain
[2]Department of Economic and Financial Studies, Miguel Hernandez University, Elche, Alicante, Spain
[3]Department of Vegetable Production and Microbiology, Miguel Hernandez University, Orihuela, Alicante, Spain
[4]Department of Physics and Computer Architecture, Miguel Hernandez University, Orihuela, Alicante, Spain

Quality and fruit colour change in Verna lemon

I. Porras[1], J.M. Brotons[2], A. Conesa[3], R. Castañer[4*], O. Pérez-Tornero[1], F.J. Manera[4]

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Summary

While most lemon cultivars in the northern hemisphere are harvested in autumn-winter, Verna, an autochthonous Spanish cultivar, is harvested later (February to August), supplying the European market when lemons are in short supply, a market that is also served by imports from the southern hemisphere, mainly Argentina and South Africa. The aim of this study was to determine the temperature at which degreening begins naturally in Verna lemon, noting the evolution of colorimetric parameter **a** and comparing the same with the equivalent measurements made in Eureka lemon, the most widely cultivated lemon worldwide. The influence of solar radiation on the colorimetric parameters in Verna was studied, and the influence of the minimum temperatures on the change from green to yellow, using the data collected over five growing seasons, was assessed. The results confirmed the relation between net solar radiation and degreening, a process that begins when net solar radiation reaches a value of between 2 and 4 MJ/m^2.day and when the mean temperature of the 14 days prior to sampling is 8.8 °C or when the daily mean temperature reaches 5.5 °C on two consecutive days. The information obtained will enable growers to predict the colour changes that will occur in the field and potential growers to ascertain whether a given geographical zone is suitable for the crop in question.

Introduction

Verna (Berna or Vernia) is an ancient cultivar (Hodgson, 1967; Ortiz et al., 1984; Russo and Spina, 1985), which blooms several times a year, but mainly in spring. The fruits in the first flowering period contain few seeds and are harvested later than most lemons (February to August) (García-Lidon et al., 2003; Ortiz et al., 1984; Porras, 2014; Russo and Spina, 1985; Saunt, 1990). Suitable cultivation techniques can favour summer flowering, which produces fruit that can be harvested the following summer (known as ("rodrejos" in Spanish and "Verdelli" in Italian). Verna fruits keep well on the tree and in storage rooms; they are also resistant to handling and transport (Porras, 2014). Until the 1970s, Verna was the most widely cultivated lemon in Spain, but has since been superseded by Fino. Of the more than 39,000 ha dedicated to lemon cultivation in Spain, 12 000 are dedicated to Verna, with an annual production of 190 000 tons (Magrama, 2014). This cultivar supplies the European market at a time (spring-early summer) when lemons are in scant supply (Porras, 2014; Saunt, 1990), since the harvesting of autumn-winter cultivars has finished and competition from the southern hemisphere does not begin until the end of May.

Eureka is perhaps the most widely grown lemon cultivar in the world, especially in California, South Africa, Chile and Australia It is very productive and rapidly enters into production. However, the tendency of the fruit to appear at the end of branches makes it very susceptible to the cold and attack by *Aceria sheldoni* Ewing. It therefore needs special cultivation practices and, moreover, it is not a long-lasting tree (García-Lidon et al., 2003).

When night temperatures fall at the end of October-beginning of November, the chlorophylls present in the rind of Verna begin to degrade (Sinclair, 1984; Soni and Randhawa, 1969), and yellow carotenoids, which have already begun to be synthesised but were previously masked by the green colour, manifest themselves in the typical "lemon yellow" colour of the fruit.

This colour indicates the stage of ripeness and stimulates the perception of freshness on the part of the potential customer (Hutchings, 2003; Joshi, 2001). The quantity of carotenoids in citrus fruit is very high (Gross, 1977; Lee and Coates, 2003; Meléndez-Martínez et al., 2007a, b, 2010) but in lemon the total concentration of carotenoids is lower than in other citrus (Yokoyama and Vandercook, 1967; Katoet al., 2004). The principal carotenoid is β-cryptoxanthin (Katoet al., 2004). The decline in rind chlorophyll takes several months and the onset of carotenoid accumulation almost coincides with the disappearance of chlorophyll (Spiegel-Roy and Goldschmidt, 1996). Degreening with ethylene is practised when lemons have not yet degreened, especially in early cultivars (Grierson et al., 1986; Conesa et al., 2014).

The lemon cultivars Eureka, Lisbon and Fino are generally harvested green before undergoing degreening in an ethylene chamber. The colour change that they undergo on the tree is similar in all three cultivars (Manera et al., 2012 a, b), while Verna differs in this respect. This cultivar takes on its characteristic yellow colour later and can therefore be left longer on the tree, meaning that it does not need to be degreened artificially to reach an acceptable commercial colour.

The aim of this study was to monitor the natural change in colour that takes place in Verna and compare its behaviour with that of Eureka, the most widely grown cultivar in the world (Saunt, 1990). We also study whether Verna needs lower temperatures than Eureka for natural degreening to begin, and the influence that net solar radiation has on the colour change. Verna fruit quality in spring, when no other cultivar in the northern hemisphere can supply the market, is analysed, but no comparison is made with the other cultivars (Eureka, Lisbon and Fino) since they are not available at this time.

The results obtained should be of interest for planning lemon plantations in new areas, based on natural degreening, with the aim of increasing the supply of lemons at a time of the year when the autumn-winter cultivars have ceased to produce.

Material and methods

Plant material

The cultivar used in this study, Verna clone 51 on *Citrus macrophylla* rootstock, is designated as a spring-summer harvesting cultivar. Its behaviour was compared with that of the widely cultivated cultivar, Eureka on *Citrus macrophylla* rootstock. Although *Citrus*

* Corresponding author

macrophylla is an excellent rootstock and is well adapted to crop conditions of the Mediterranean area, care must be taken when using nitrogenated fertilization in Verna grafted onto this rootstock since, otherwise, the fruit has a tendency to grow too big and have a thick rind. Verna grafted on *Citrus macrophylla* is also more sensitive to injury than when grafted onto sour orange (Riquelme et al., 2008).

Site description and experimental conditions

The two cultivars were planted in April 1983 in a plot at IMIDA (Murcia Institute of Agriculture and Food Research and Development), La Alberca (Murcia, SE Spain). Trees were spaced 6 × 6 m. The soil is permeable and calcareous (17.1% total calcium carbonate). All the trees used in the study were healthy and in full production. Drip irrigation was used with five emitters per tree, with a flow rate of 4 l/h. Water pH was 7.15, electrical conductivity 3.8 dS/m, Cl^- 8.63 mmol/l, Na^+ 12.28 mmol/l, Ca^{2+} 10.70 mmol/l, K^+ 0.79 mmol/l and Mg^{2+} 10.65 mmol/l. Potassium nitrate, ammonium nitrate (34%), monoammonium phosphate and iron chelate were applied weekly from the first year of planting. Zn and Mn fertilizers were sprayed in spring. The trees were cultivated, pruned and sprayed with insecticides and fungicides, according to local practices. The annual average temperature is 18.4 °C, with a mean maximum temperature of 31.1 °C and mean minimum temperature of 4.5 °C. Mean annual rainfall is 321 mm (SIAM, 2015).

Data analysis

The external colour of the fruit was measured in the HunterLab colour space (Hunter, 1967) with illuminant C as representative of daylight (MacDougall, 2002), using a Minolta C-300 reflection colorimeter: tristimulus with double light path in the visible light range, standard observer angle CIE-2° and white calibration plate. Three readings were taken in the equatorial zone of each fruit. In each reading, the colorimetric coordinates **L**, **a** and **b** were measured. The colour coordinate **L** measures lightness (100 for white and 0 for black). The colour coordinate **a** corresponds to the green-red axis, where the negative values correspond to green and the positive to red (-60 green, +60 red) (Hutchings, 1994; MacDougall, 2002), and the colour coordinate **b** measures variations from blue to yellow (-60 blue, +60 yellow). Any decrease in the chlorophyll content of the fruit is associated with coordinate colorimetric **a** (Kidsome et al., 2002; Manera et al., 2012a).

Hue angle ($\mathbf{h_{ab}}$) is defined as the angle between the hypotenuse and 0° on the **a** (bluish-green/red-purple) axis; $\mathbf{h_{ab}}$ is calculated from the arctangent of **b/a** (Little, 1975; McGuire, 1992).

Colour differences expressed by ΔE_{ab} were calculated using L, a and b as geometric coordinates in the following formula: $\mathbf{\Delta E_{ab}} = [(\mathbf{\Delta L})^2 + (\mathbf{\Delta a})^2 + (\mathbf{\Delta b})^2]^{1/2}$. Values above 3 indicate that the colour perceived by the human eye is different (Manresa and Vicente, 2007).

The relation between net radiation, measured in MJ/m^2.day as described by Allen et al. (1998), and the colorimetric coordinates was also studied.

Temperature and data for calculating net radiation, as described by Allen et al. (1998), were provided by a weather station in the same plot, observatory MU62 of La Alberca, Murcia, which forms part of the network that IMIDA maintains in the most important growing regions of the province of Murcia (SIAM, 2015).

Net radiation (Rn) is the difference between the incoming and outgoing radiation at long and short wavelengths. It is the balance between the energy absorbed, reflected and emitted by the earth's surface (Rb). Rn is the radiation that remains in the crop and is calculated by deducting from the radiation that reaches the earth's surface (Rs) the reflected radiation (which depends on the albedo) and the losses of long wave length radiation (Rb), which depend on the temperature, cloud cover and humidity level. Rn is normally positive during the day and negative during the night (Allen, 1998).

$Rn = (1- \alpha) \times Rs - Rb$, where Rs = incident solar radiation.

The radiation that reaches the earth's surface (Rs) can be calculated as a function of latitude, time of the year and cloud cover. The index α indicates the incident radiation that is reflected by the surface, and is known as "albedo", with a value of between zero and one. For crops with more than 80% soil cover, $\alpha = 0.23$. A green vegetation cover has an albedo of about 0.20-0.25. For the green grass reference crop, α is assumed to have a value of 0.23 (Allen et al., 1998). Rb represents losses of long wave radiation from the surface. Rn is measured in MJ/m^2.day.

The relation between net radiation, measured in MJ/m^2.day, and the colorimetric coordinates was also studied. To smooth the radiation series and improve the correlation between net radiation and the colorimetric coordinates, the net radiation mean of the previous 14 days was used.

From March to May, random samples of 15 fruits were harvested from each of the four Verna trees analysed. The samples were weighed; fruit width (W) and peel thickness (T) were measured after cutting in half with a digital caliper and then the size; thickness indices ($2 \times T \times 100 / W$) indices were calculated.

Juice was extracted with an electric juicer. The resulting juice and the flesh were collected in a mesh bag (1 mm) and the remaining juice was extracted by squeezing the bag by hand until no juice remained. The juice content (%), total soluble solids (TSS) and titratable citric acid (TA) were calculated. TSS was determined by an Atago digital refractometer (at 20 °C) and TA by titration with 0.1N NaOH, using phenolphthalein indicator (Anonymous, 1946).

To quantify the organic acids present in the lemon juice (citric, malic, oxalic, tartaric, ascorbic and fumaric), their evolution was studied during maturation. The juice was centrifuged for 10 minutes at 7500 rpm at 4 °C, using a Selecta model 540 centrifuge, and filtered through 0.45 µm filters before being introduced in the chromatograph for analysis. A Hewlett Packard 1100 (HPLC) was used with a Nucleosil column (12.5 × 0.4 cm; 3µm particle size). The mobile phase was a 0.01 M solution of KH_2PO_4 taken to pH 2.25 with H_3PO_4. The injection flow was 1 ml/min and the wavelength 206 nm.

The data obtained were not compared with those of other cultivars because, at the time at which the Verna samples were taken, no other cultivar bears fruit.

Experimental design

At the beginning of the experiment, ten fruit (from inside the canopy, 5 north-facing and 5 south-facing) were labelled at random on four trees of each cultivar (40 fruits per cultivar – a total of 80 fruits between both cultivars per year). The colour of the fruit was measured by colorimeter every 7-15 days from September to January in Eureka, and until April-May in Verna, during the 2007/08, 2008/09, 2009/10, 2010/11 and 2011/12 growing seasons, providing approximately 13 measurements per year.

To analyse the relation between the 14-day daily mean temperatures and the different colorimetric coordinates, the receiver operating characteristic curve (ROC) was used since this shows the sensitivity (the probability that the colorimetic coordinate **a** will reflect the fact that degreening has begun when it really has begun) and the specificity (the probability that the coordinate will predict that degreening has not begun when it really has not). The ROC curve is the plot that displays the full picture of trade-off between the sensitivity (true positive rate) and (1- specificity) (false positive rate) across a series of cut-off points. As turning point temperature (responsible for initiating the process), we took the temperature at which the sum of both (sensitivity and specifity) was maximum. For this purpose, SPSS 22.0.0.0 was used.

Below, we determine the mean 14-day temperature at which this degreening process begins, taking the mean temperature of 14 days as test variable and another dichotomous variable (denominated a_01), which indicates whether the process has (a_01=1) or not (a_01=0) begun:

$$a\_01 = \begin{cases} 0 & a < a^* \\ 1 & \text{otherwise} \end{cases} \quad (1)$$

For each a*, a ROC curve was constructed (Fig. 1), and the a* curve for which the sum of the sensitivity and (1-specificity) is maximum was selected. This curve corresponds to the value of the mean 14-day temperature at which this degreening process begins.

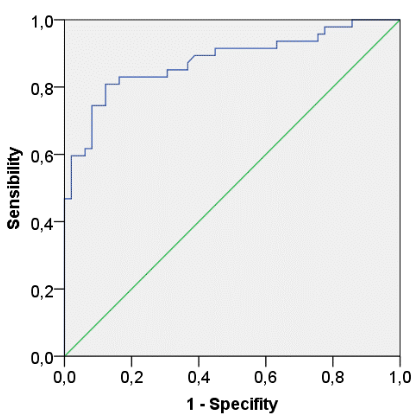

Fig. 1: ROC curve constructed from sensitivity and 1-specifity

Results and discussion

Evolution of the colorimetric coordinate *a*

The evolution of temperatures and coordinate **a** (Eureka and Verna cultivars) during the degreening process of 2012/13 are represented in Fig. 2, where the differences in how the degreening process proceeds in both cultivars can be seen. In Eureka degreening (measured as the increase in colour coordinate **a**) begins two weeks earlier and takes place much more rapidly than in Verna. Moreover, Verna never reaches the values that are attained by Eureka.

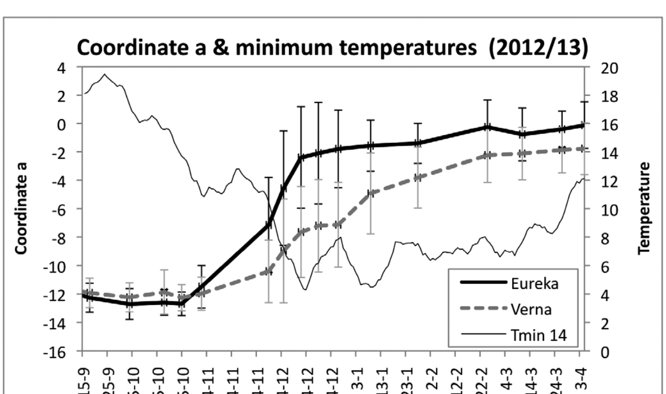

Fig. 2: Evolution of coordinate a (Eureka and Verna cultivars) and mean minimum temperatures and standard deviation of the 14 days from September 2012 to May 2013.

Below, we study whether Verna needs lower temperatures to reach a similar degreening level as Eureka.

If colour coordinate **a** remains above -2 in Verna (Fig. 2) the fruit can be kept on the tree another three months without losing its commercial quality, unlike Eureka and other autumn-winter cultivars (e.g. Lisbon and Fino), which, once they reach **a** values above 0, begin to senesce and must be harvested before they fall to the ground.

To ascertain whether differences in rind colour between Eureka and Verna can be appreciated visually, the value of ΔE_{ab} was calculated (Fig. 3).

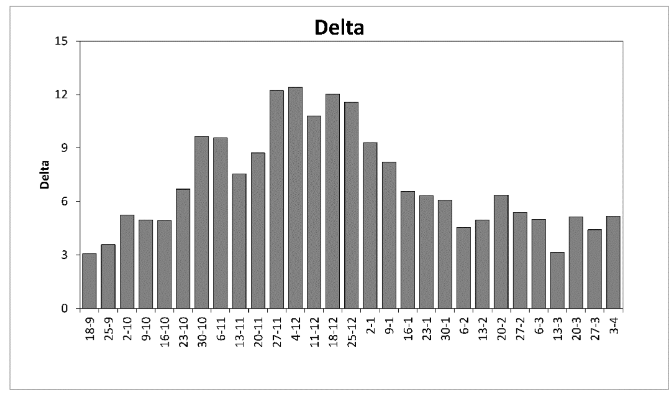

Fig. 3: Evolution of ΔE_{ab} in Eureka and Verna; mean values for the six harvests.

When ΔE_{ab} is above 3, the fruit of both cultivars can be distinguished colorimetrically (MANRESA and VICENTE, 2007).

The colour differences are higher in November and December, as is shown in Fig. 3 and in accordance with Fig. 2.

Influence of net solar radiation on degreening

Although temperature is considered the most important trigger of the degreening process (MANERA, 2012 a, b; SINCLAIR, 1984), the influence of solar radiation on Verna degreening was also studied.

Fig. 4 shows the evolution of mean net solar radiation (MJ/m^2.day) and colour coordinate **a**. At the beginning of autumn, net radiation reached values close to 12, falling as the year progressed. In all the years studied degreening (disappearance of chlorophyll) began at Rn values of ≤ 4 MJ/m^2.day (during the first week of December). In the growing seasons of 2008 and 2009, the process began with Rn values close to 2 MJ/m^2.day and in 2007 and 2012 at a slightly higher value, around 4 MJ/m^2.day.

In 2007, 2008 and 2009, when Rn ≥ 6 MJ/m^2.day (at the very end of winter, during the first week of March), the **a** value began to fall and the rind of Verna turned from yellow to greenish. This agrees with the results of other studies, for example in the orange cultivar Valencia, whose rind begins to turn green again, when the temperatures begin to rise (SOLER and SOLER, 2006; THOMSON et al., 1967; YOUNG et al., 1961).

Net solar radiation and degreening are related, the process beginning when NR falls to values of 2 and 4 MJ/m^2.day (Fig. 3).

Relation between minimum temperature and colour coordinates

Fig. 5 shows the evolution of the mean values of colour coordinates **L**, **a** and **b** and of hue angle for Verna and Eureka, and the mean minimum temperatures for the 14 days preceding the measurements. Although previous studies have taken the mean values for 21 days (MANERA et al., 2012 a, b), there is scant improvement in the correlations between variables with this increase in time, so we opted for a 14-day period.

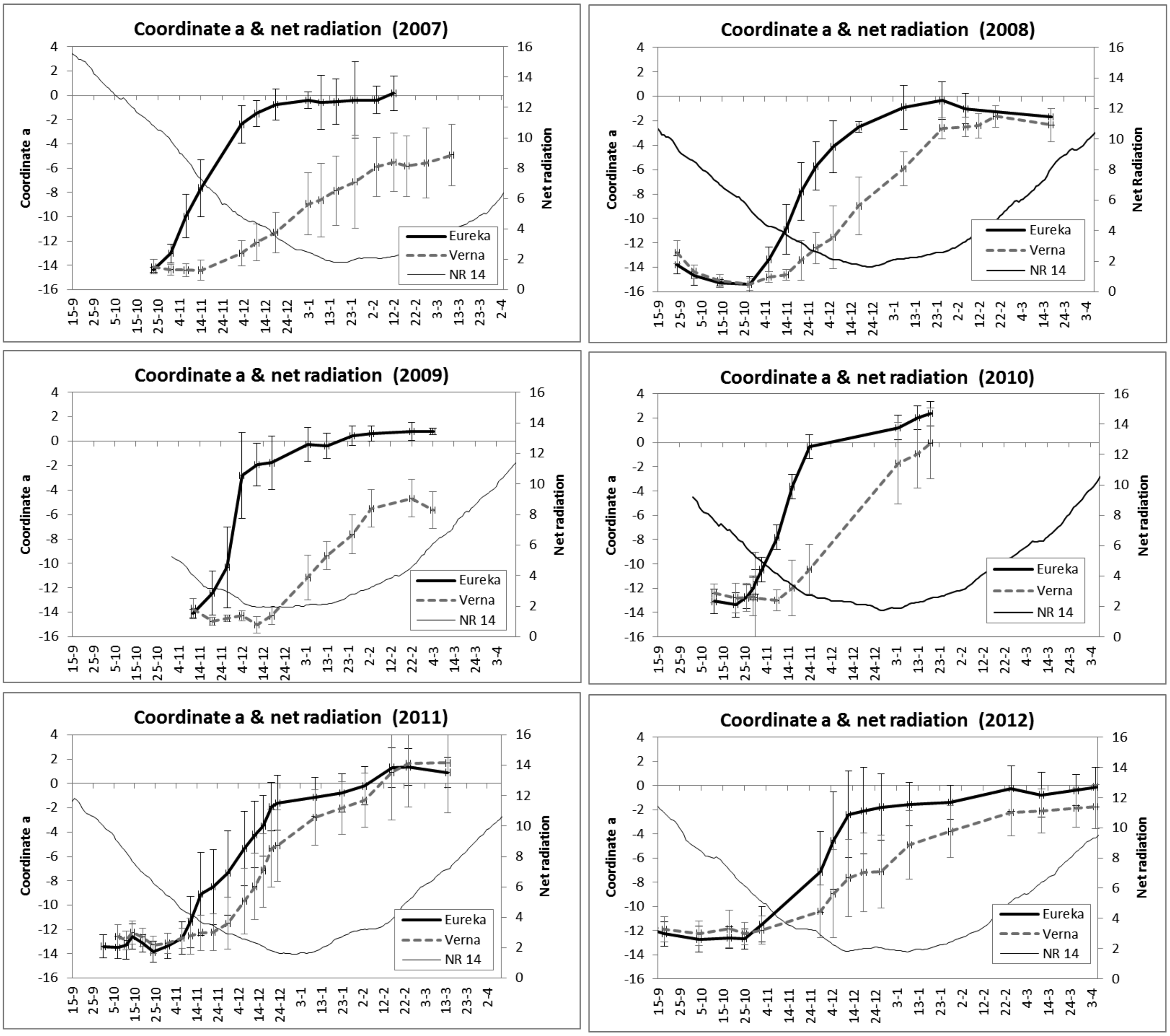

Fig. 4: Evolution of coordinate **a** and net radiation (mean of 14 days preceding the measurement, and standard deviation) for seasons 2007 to 2012.

Note that the series corresponding to Eureka finish in mid-January, when the condition of fruit on the tree ceases to be commercially acceptable, while, at the same time, the fruit of the Verna cultivar are still on the tree and can remain so for a further 3 months with no loss of quality.

Of note is the fact that all three colour coordinates (**L, a,** and **b**) and hue angle begin to change earlier and progress more rapidly in Eureka than in Verna. Moreover, the final coordinate values reached are in general higher in Eureka, while the hue angle is, by its very definition, lower.

- Coordinate **L**. In Verna this coordinate does not begin to increase until the second week of November, when mean minimum temperatures for the previous 14 days fall below 10 °C, whereas the same parameter begins to change one month earlier in Eureka (mean minimum temperatures of around 16 °C), which agrees with the results of MANERA et al. (2012 a, b). However, the final values reached by **L** were similar in both Verna and Eureka (67-68).
- Coordinate **a**. In Verna degreening begins with mean minimum temperatures for the previous 14 days of around 9 °C, and occurs later than in the case of Eureka (around 16 °C), coinciding with the results of MANERA et al. (2012 a, b). However, **a** increases more slowly in Verna than in Eureka, in which the parameter reaches positive values (giving it a slightly reddish tone and the appearance of older fruit), while in Verna the same parameter only reaches values of around -2 (greenish yellow and younger in appearance).
- Coordinate **b**. This begins with values that represent a yellowish colour (20-22), although masked by the green colour of the chlorophyll. The increase in yellow begins with when mean minimum temperatures 14 reach about 13 °C, while the final values are 35 and 38 in Verna and Eureka, respectively (slightly yellower).
- Lastly, hue angle in Verna reaches 95 but does not exceed 90 in Eureka, meaning that Verna appears yellowish green and Eureka yellow.

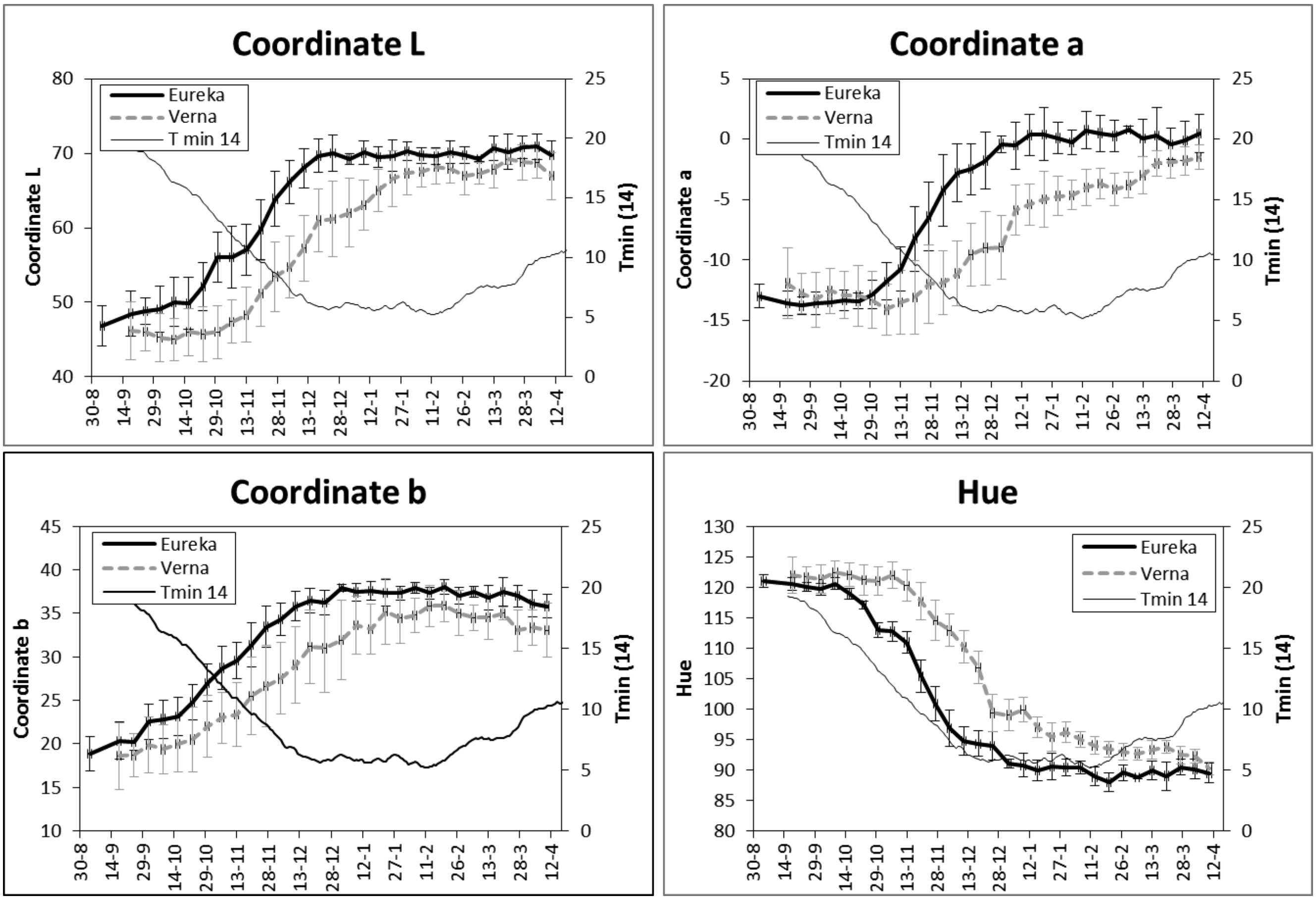

Fig. 5: Evolution of colour coordinates **L**, **a** and **b**, hue angle and mean minimum temperatures (and standard deviation) for the 14 preceding days in Eureka and Verna cultivars. Values are the means of all the growing seasons analysed.

Determination of 14-day minimum temperature, below which degreening begins

Fig. 4, which depicts the evolution of coordinate **a** and net radiation for each of the six seasons studied, suggests that degreening begins when colorimetric coordinate **a** exceeds – 11.

Below, we determine the mean 14-day temperature at which this degreening process begins, taking the mean temperature of 14 days as test variable, and another dichotomous variable we denominate a_01, which indicates whether the process has (a_01=1) or not (a_01=0) begun:

$$a\_01 = \begin{cases} 0 & a < -11 \\ 1 & \text{otherwise} \end{cases} \quad (2)$$

Using these two variables a ROC curve was constructed for each temperature (test variable). Different sensitivity and specificity values were obtained for each point of the ROC curve. The highest sum was taken.

This process was repeated for different values of the test variable (temperature), taking the highest sum of the sensitivity and specificity of each curve. Finally, the maximum value of these sums was taken. The result corresponds to a mean minimum 14-day temperature of 8.8 °C. In other words, the value at which degreening in Verna begins (9 °C in the above sections) (Fig. 4) can now be corrected to 8.8 °C with the ROC curve. Therefore, it can be affirmed that the 14-day mean minimum temperature for degreening to begin is 8.8 °C.

Determination of daily minimum temperature below which degreening begins

Besides the relation observed between the mean minimum temperatures of 14 days and the colorimetric coordinates, we also studied how the degreening process is triggered by analysing the daily minimum temperatures and colorimetric coordinates. Since coordinate **a** was seen to best explain the changes in yellowness (degreening), the relation is shown for the six years of the study.

Taking the daily temperature as test variable and the dichotomous variable we denominate a_01, which indicates whether the process has (a_01=1) or not (a_01=0) begun, and repeating the same process as in the previous section, the daily minimum temperature for degreening to begin was found to be below 5.5 °C.

Physical-chemical characteristics of the fruit

When the harvesting of autumn-winter cultivars of (Eureka, Lisbon and Fino) finishes, the largest Verna fruit can be picked, and the rest can be left on the tree for forthcoming months since they will maintain their condition (García-Lidón et al., 2003; Porras, 2014). However, care must be taken with irrigation and fertilisation to avoid excessively large fruit.

In the time period studied in this work, the fruit reached their commercial size of 58-63 mm (Tab. 1) and were suitable for marketing. If they are not harvested in April or May, many of the fruit grow too big for commercial purposes, although they remain in good condition on the tree. Rind thickness is also excessive after April,

Tab. 1: Characteristics of Verna lemon fruit in different dates

	02/03	24/03	19/04	18/05
Weight (g)	145.4±2.1	159.6±2.8	168.8±3.8	174.4±4.1
Diameter (mm)	59.9±0.0	61.6±0.2	63.1±0.7	64.0±0.8
Rind thickness	5.9±0.1	5.9±0.1	6.8±0.1	6.7±0.2
Thickness index	19.8±0.4	19.2±0.3	21.7±0.3	20.9±0.6
% juice	28.6±1,0	34.4±0.7	33.4±0.7	32.5±0.7
Acidity (g/L)	54.9±0.5	50.0±0.9	48.5±0.8	45.3±0.9
ºBrix	6.7±0.1	6.5±0.1	6.2±0.1	5.6±0.1

although the rind tends to be thicker in Verna than in other cultivars at all times (Ortiz et al., 1984; Pérez-Pérez et al., 2005). This characteristic and the low levels of essential oils in the rind make Verna more resistant to damage from handling, storage and transportation (García-Lidón et al., 2003; Porras, 2014; Riquelme et al., 2008).

In general, fruits from trees on *Citrus macrophylla* have higher TA and TSS levels in March than in mid-May (54.9 g/l. and 6.7 °Brix, compared with 45.3 g/l and 5.65 °Brix, respectively). Acidity is lower in Verna than in Eureka, Lisbon and Fino (Ortíz et al., 1984). Eureka grafted on *Citrus macrophylla* shows higher acidity (67.8 g/L) in autumn (Perez-Perez et al., 2005), than was observed in our study.

The percentage of juice, acidity and °Brix of Verna are lower than in other cultivars (Ortiz et al., 1984; Perez-Perez et al., 2005).

The organic acid with the highest concentration in Verna was citric acid (92.16%), followed by malic acid (4.45%), which reflects the findings of Sinclair (1984). Other organic acid are present in very low proportions (Tab. 2).

Tab. 2: Organic acid contents of Verna lemon fruit in different dates

Organic acid	02/03	24/03	19/04
Citric (mg/mL)	32.3±8.5	27.7±2.3	29.3±3.8
Malic (mg/mL)	1.8±0.4	1.4±0.2	1.2±0.2
Oxalic (mg/100 mL)	15.7±3.0	28±2.1	11.1±2.2
Tartanic (mg/100 mL)	43.8±10.4	45.1±5.5	47.2±7.6
Fumaric (mg/100 mL)	5.9±3.8	5.4±0.7	4.0±1.0
Ascorbic (mg(100 mL)	47.2±9.4	39.1±3.6	40±5.5

The differences between total acidity expressed as anhydric citric acid and the sum of the organic acids can be attributed to the fact that aminoacids, polyphenolic substances and oxidryl radicals are evaluated in titratable acidity (Rolle and Vandercook, 1963, cited by Sinclair, 1984).

The ascorbic acid values were higher than those obtained in Verna lemon by Marín et al. (2002) (26.1 mg/100 ml). In general the values reflect those obtained by García Lidón et al. (2003) and Sinclair (1984) for numerous lemon cultivars throughout the world.

In general the overall quality of Verna is lower than that of autumn-winter cultivars (Eureka, Lisbon, Fino), but it has the advantage of being able to supply the European market when the others have finished and before lemons arrive from the southern hemisphere (García-Lidón et al., 2003; Porras, 2014). They exceed the quality standards set for export to European markets (DOGV, 2006).

Conclusions

1. There was a clear relation between net solar radiation and the degreening of Verna lemon in the growing seasons studied. Degreening begins when net radiation reaches between 2 and 4 MJ/m^2.day
2. In Verna degreening begins when mean minimum temperatures of 14 days fall below 8.8 °C, as obtained by curve the ROC calculation.
3. Degreening in Verna can also be said to begin when the daily minimum temperatures reach 5.5 °C.

New plantations of Verna will not be viable in any part of the world if the minimum temperature does not fall below 9 °C since fruit quality will not be sufficient for the fresh market. Similarly, it must be borne in mind that both the beginning of degreening and its progress need Rn values of ≤ 4 MJ/m^2.day.

In the climatic conditions of the inland valleys of the province of Murcia, Verna would need 14 days with mean temperatures below 8.8 °C for the natural degreening process to begin on the tree. The fruit of Verna remains on the tree during winter months and the beginning of spring, maintaining a stable yellow colour and remaining fresh in appearance. This permits the fruit to be harvested late (until the beginning of summer) with the fruit still in good condition.

Although overall quality of Verna lemons is lower than that of autumn-winter cultivars, the fruit comply with quality norms and can supply the European market when no other cultivar is available and before the arrival of lemons grown in the southern hemisphere.

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Address of the authors:

I. Porras, O. Pérez-Tornero, Department of Citriculture, Murcian Institute of Agriculture and Food Research and Development (IMIDA), Estación Sericícola, Calle Mayor s/n. 30150, La Alberca, Murcia, Spain.

E-mail: ignacio.porras@carm.es

J.M. Brotons, Department of Economic and Financial Studies, Miguel Hernandez University, Avda. de la Universidad, s/n, 03202, Elche, Alicante, Spain.

E-mail: jm.brotons@umh.es

A. Conesa, Department of Vegetable Production and Microbiology, Miguel Hernandez University, Ctra de Beniel, km 3.2, 03312 Orihuela, Alicante, Spain.

E-mail: agustin.conesa@umh.es

R. Castañer, F.J. Manera, Department of Physics and Computer Architecture, Miguel Hernandez University, Ctra de Beniel, km 3.2, 03312 Orihuela, Alicante, Spain.

E-mail: fco.manera@umh.es

E-mail corresponding author: r.castaner@umh.es