



## Maturation of early-ripening mandarin as affected by scion and rootstock cultivars in western Santa Catarina, Brazil<sup>1</sup>

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### ABSTRACT

In Santa Catarina, Brazil, ‘Satsuma Okitsu’ and the ‘common mandarin’ (*Citrus deliciosa* Ten.) are the widely known mandarin varieties harvested earlier than ‘Ponkan’. This study analyzed and compared the maturation evolution of early maturing mandarins in two rootstocks. The experiment had as treatments combinations of the scion cultivars SCS458 Osvino, Clemenules, Satsuma Okitsu and Mexirica do Rio IAC and the rootstocks ‘Swingle’ and ‘IAC 387 Carrizo’. Fruit were sampled during ripening to evaluate soluble solids (SS), total acidity (TA), ratio (SS/TA), juice content and skin color (CIE Lab parameters and color index - CI). Treatments were compared by analysis of variance and linear and nonlinear modeling. Scions significantly affected the evaluated variables, but no rootstock effect was found. ‘SCS458 Osvino’ showed earlier ratio and, mainly, CI, but its juice content was low in part of the period. ‘Satsuma Okitsu’ and ‘Clemenules’ presented, early, higher CI and ratio than ‘Mexirica do Rio IAC’. In conclusion, the cultivars SCS458 Osvino, Satsuma Okitsu and Clemenules are more precocious in maturation compared to ‘Mexirica do Rio IAC’, and the first is the most precocious in peel maturation.

**Keywords:** citrus; acidity; soluble solids; color; C.I.E.-Lab.

### INTRODUCTION

Brazil harvests around 50 thousand hectares of mandarin orchards (here included satsumas, mandarins and clementines). Twenty one thousand are found in southern states. Cerro Azul (Paraná) and Montenegro (Rio Grande do Sul) are the main producer micro regions. In Santa Catarina state, most orchards are located in the micro regions of Rio do Sul and Concórdia (Instituto Brasileiro de Geografia e Estatística - IBGE, 2018).

Citrus ripening is determined based on four main characteristics: juice soluble solids content (SS) – positively correlated with sugar content, mainly fructose, glucose and sucrose; juice titratable acidity (TA) – which is conferred mainly by citrate and malate; peel color – green given by chlorophyll and yellow-orange by

carotenoids; and juice content, what is expected to be more than 35%. During maturation, SS rises, TA is reduced, green peel gets yellow or orange (Albertini *et al.*, 2006; Manera *et al.*, 2013; Khosravi *et al.*, 2015) and juiciness rises but tends to fall in the end of maturation. The division of SS by TA results in ripening index (RI), or ratio, which is the more widely used parameter to determine table citrus harvesting time.

In Santa Catarina, mandarin harvest is concentrated from April to August, mainly as consequence of a restrict cultivar composition. No data are available on the amount of fruit harvested or commercialized by cultivar, but it is known when ‘Ponkan’ (*Citrus reticulata* Blanco) gets ripe, prices go significantly depressed. So, producing earlier-ripening cultivars can be an opportunity for growers to attain higher profits. In the west, ‘Satsuma Okitsu’ (*C.*

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*unshiu* Marc.) and ‘Mexirica do Rio IAC’ or “common mandarin” (*C. deliciosa* Ten.) are the only widely grown and known varieties which can be harvested before ‘Ponkan’, main market cultivar (Koller & Soprano, 2013). Recently, some early-maturing clementine (*C. clementina* Hort. ex Tan.) varieties aroused the interest for cultivation, and a new cultivar of *C. unshiu* - ‘SCS458 Osvino’, was released, and it is considered more precocious than ‘Satsuma Okitsu’ based in preliminary data obtained in eastern Santa Catarina (Maro *et al.*, 2018).

Those early-maturing mandarins are especially interesting for cultivation in warm regions, because the higher the thermal sum, the earlier the harvest (Stenzel *et al.*, 2006). In western Santa Catarina, there are lands with elevation from 300 to 600m, under a Köppen Cfa climate, where temperatures are relatively high, ensuring a precocious maturation of mandarins. However, in such condition, the peel of early harvest fruit tends to delay in acquiring yellow/orange color, since loss of chlorophyll and rise of carotenoids are dependent of low minimum air temperatures (Manera *et al.*, 2013).

The objective of this research was to analyze and compare the ripening evolution of alternative, early-maturing mandarin cultivars budded in ‘Swingle’ and ‘IAC 387 Carrizo’ rootstocks.

## MATERIAL AND METHODS

Evaluated fruit were taken from an experiment located in Águas Frias municipality, Santa Catarina state, in Chapecó river valley (26.84406°S, 52.868725°O, 378m elevation). An split-plot experiment was designed in random blocks, having the scion cultivars the satsumas ‘SCS458 Osvino’, ‘Satsuma Okitsu’ (*C. unshiu* Marc.), the clementine ‘Clemenules’ (*C. clementina* Hort. ex Tan.) and the willow leaf mandarin ‘Mexirica do Rio IAC’ (*C. deliciosa* Ten.) as main treatment, and in subplots the rootstocks ‘Swingle’ - *C. paradisi* Mac. x *Poncirus trifoliata* (L.) Raf., and ‘IAC 387 Carrizo’ - *C. sinensis* (L.) Osb. x *P. trifoliata* (L.) Raf.]. Trees were planted November 2010, spaced 7x3m. Fertilization consisted in manure supply.

In 2016 and 2017 harvest seasons, when the orchard was 7 and 8 years old, fruit were sampled from February to June, depending on the expected ripening time for each cultivar and sensorial aspects of fruit (taste, color, size and firmness). Each sample (one per subplot) was composed by 12 fruit collected near 1.5m height from the canopy’s periphery. Peel color was accessed in two points at the equatorial line of each fruit (the greenest and the more orange/yellow) using a color meter (Konika-Minolta CR-400). The parameters *L*, *a* and *b* from C.I.E.-Lab color space were averaged and used to calculate the color index (CI= 1000\*a/L\*b) (Jimenez-Cuesta *et al.*, 1981). The same

fruit were weighted and submitted to juice extraction for determination of juice content, soluble solid content (SS, determined by refractometry) and titrable acidity (TA, by NaOH titration until pH 8). Then RI was calculated dividing SS by TA.

Once each year (March 28, 2016 and April 04, 2017) all scions were evaluated at same date for RI, juice content and CI, such data were submitted to an analysis of variance and Tukey test. Linear and non-linear models were fitted having as independent variable the number of days after December 31, i.e. January 1<sup>st</sup> is day 0, correspondent to harvest date. The models tested were first and second grade linear models, the nonlinear models Monomolecular [  $y=A_u-(A_u-y_0)*\exp(-r*x)$  ] and Mitscherlich [  $y=A_u*(1-\exp^{(\log(1-0.99)*((x-b_3)/(b_2-b_3)))})$  ], both reparametrized by Zeviani (2013), where  $A_u$  is the upper asymptote,  $y_0$  is the intercept,  $r$  is a rate of increment in  $y$ ,  $b_2$  is the number of days necessary for reaching 99% of  $A_u$ ,  $b_3$  controls the function’s shape,  $x$  is time and  $y$  response variable; and, once some data ( $y$ ) were expected to grow from negative to positive values, it was tested a two-asymptote logistic model  $y = A_l + ((A_u - A_l)/(1 + (x / I)^{-H}))$ , where  $A_l$  is the lower asymptote,  $A_u$  is the upper asymptote,  $I$  is the inflexion point in ordinate axis,  $H$  is the hill of the curve,  $x$  is the time and  $y$  the response variable. The best-fitting model for each treatment and season was selected based the minor Akaike information criterion (AIC). Treatments with same model fitted were compared observing its 95% confidence intervals for the model parameter estimates. All analyses were performed with R (R Core Team, 2018), amended with “minpack.lm” (Elzhov *et al.*, 2016).

Data on mean air temperature registered in the nearest (in distance and elevation) weather station (Maravilha municipality) were cordially provided by the Centro de Informações de Recursos Ambientais e de Hidrometeorologia de Santa Catarina (Epagri/CIRAM, Brazil) (Figure 1).

## RESULTS AND DISCUSSION

Following the variance analysis for variables measured at same date each season, no significant difference was observed between rootstocks neither significant scion x rootstocks interaction. However, all variables analyzed were affected by scions (Table 1).

When comparing models fitted for RI and CI with two rootstocks inside each scion cultivar, no difference was found since confidence intervals for model parameters were coincident, which corroborates the analysis of variance. Because of that, further analyses were performed with two rootstocks combined. In some cases, for a same scion cultivar the models fitted in two seasons were different (Table 2 and 3).

### Juice properties

Observations on SS and TA are presented in Figure 2. 'Mexirica do Rio IAC' and 'Clemenules' reached higher values of SS than the Satsumas 'Satsuma Okitsu' and 'SCS458 Osvino' both seasons. In addition, for both Satsumas SS varied little along the period considered. 'Clemenules' showed higher values of SS than all others in both seasons. The four scions were more alike in range of TA than SS (Figure 2). However, variation in 'Clemenules' juice along the time was smaller. Juice of 'Mexirica do Rio IAC' showed higher SS, but in the beginning of the season TA was higher too, resulting lower RI.

In 2016, RI of 'Satsuma Okitsu' and 'Clemenules' grew similarly over time (Figure 3) with no significant difference (Table 2). On the other hand, the models fitted to 'Mexirica do Rio IAC' and 'SCS458 Osvino' were monomolecular and logistic. In 2017, monomolecular models fitted better to 'SCS458 Osvino', 'Satsuma Okitsu' and 'Clemenules' RI evolution with no difference in the parameters (Table 2). The response of 'Mexirica do Rio IAC' was better explained by a first degree linear equation. Juice of 'Clemenules' presented reduction of RI at the last evaluation, characterized by a quadratic model, which was due to a decrease in SS (Figure 2). When compared at

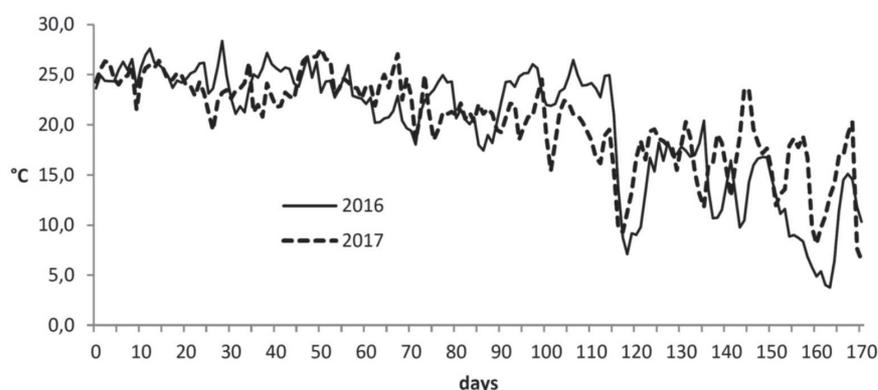
same day, 'Mexirica do Rio IAC' presented a lower RI than the other three treatments (Table 1).

### Juice content

All scions produced fruit with adequate juice content (> 35%) in some part of the evaluation period (Figure 2). 'Satsuma Okitsu', sampled until near 90 days, always had fruits adequate in juice. When all cultivars were sampled the same day (Table 1), 'Satsuma Okitsu' was significantly juicier than others at both seasons. 'Clemenules' the two years and 'Mexirica do Rio IAC' at 2017 had less than 35% at the end of season (Figure 2). Juice content of 'SCS458 Osvino' was more limiting, especially at 2016, when just two intermediate samples resulted in adequate juice content.

### Peel color

During almost the entire evaluation period, values measured for *L*, *a* and *b* grew all scions and seasons (Figure 4), but earlier in 'SCS458 Osvino', followed by 'Satsuma Okitsu', 'Clemenules' and 'Mexirica do Rio IAC'. Despite differences in sampling period among scion cultivars, values of *a* (which means more red and less green) reached higher magnitudes in 'Mexirica do Rio IAC'



**Figure 1:** Mean air temperature observed in Maravilha weather station (elevation = 573 m, approximately 30 km far) in the first semester of 2016 and 2017. (Data cordially provided by Epagri/CIRAM).

**Table 1:** Comparison of mandarin scion cultivars (mean of two rootstocks) regarding ripening index (RI) of the juice, juice content and peel color index (CI), in two harvest seasons

<i>p</i> value	88° day, 2016			94° day, 2017		
	RI	Juice (%)	CI	RI	Juice (%)	CI
scion	< 0001	< 0.001	< 0.001	< 0.001	0.002	< 0.001
rootstock	0.72	0.29	0.06	0.98	0.79	0.59
interaction	0.66	0.70	0.11	0.59	0.40	0.31
<b>Scion</b>	<b>Tukey comparison<sup>(1)</sup></b>					
SCS458 Osvino	12.31a	33.2c	-0.79a	12.0a	31.7c	1.6a
Satsuma Okitsu	12.77a	43.7a	-1.37a	12.3a	47.5a	-1.0b
Clemenules	13.32a	39.8b	-9.78b	12.8a	40.7b	-11.9c
Mexirica do Rio IAC	9.00b	41.3b	-14.17c	7.7.8b	39.4bc	-15.8d

<sup>(1)</sup>Average of two rootstocks. Means followed by the same letter inside each season do not differ statistically (Tukey test,  $\alpha = 0.05$ ).

and, mainly, in 'Clemenules'. As observed for RI, CI evolution pattern varied among scions and season (Table 3). First grade linear models were fitted to CI of 'SCS458 Osvino' both season, while for 'Satsuma Okitsu' logistic nonlinear models were more adequate. 'Mexirica do Rio

IAC' and 'Clemenules' showed different evolution patterns among seasons (Figure 3). Inside each season, the second grade model (2016) and logistic (2017) differed significantly between 'Mexirica do Rio IAC' and 'Clemenules' (Table 3), which means the latter is more precocious (Figure 3).

**Table 2:** Linear and non-linear models adjusted to the response of four scions (mean of two rootstocks) ripening index (y) to the time (x) along 2016 and 2017 harvest season. Parameter estimates are followed by the limits of its 95% confidence interval

Scion	2016	2017
<b>Mexirica do Rio IAC</b>	<b>Monomolecular<sup>(1)</sup> - R<sup>2</sup> = 0.93</b> $A_u = 18.58$ (16.59; 20.56) $y_0 = -109$ (-252; 34.1) $r = 0.03$ (0.015; 0.044)	<b>First grade model<sup>(2)</sup> - R<sup>2</sup> = 0.92</b> $a = -7.23$ (-9.62; -4.84) $b = 0.16$ (0.14; 0.18)
<b>Osvino</b>	<b>Logistic<sup>(3)</sup> - R<sup>2</sup> = 0.89</b> $A_l = 6.38$ (4.81; 7.94) $A_u = 13.50$ (11.34; 15.67) $I = 58.61$ (50.79; 66.42) $H = 6.03$ (0.66; 11.39)	<b>Monomolecular - R<sup>2</sup> = 0.79</b> $A_u = 13.91$ (9.16; 18.65) $y_0 = -3.84$ (-15.60; 7.91) $r = 0.023$ (-0.002; 0.048)
<b>Satsuma Okitsu</b>	<b>Second grade model<sup>(4)</sup> - R<sup>2</sup> = 0.78</b> $a = -4.9$ (-8.66; -1.14) $b = 0.38$ (0.25; 0.51) $c = -19e^{-4}$ (-30e <sup>-4</sup> ; -9e <sup>-4</sup> )	<b>Monomolecular - R<sup>2</sup> = 0.91</b> $A_u = 15.10$ (11.41; 18.8) $y_0 = -2.89$ (-8.31; 2.52) $r = 175e^{-4}$ (58e <sup>-4</sup> ; 293e <sup>-4</sup> )
<b>Clemenules</b>	<b>Second grade model<sup>(4)</sup> - R<sup>2</sup> = 0.84</b> $a = -5.76$ (-11.49; -0.03) $b = 0.36$ (0.24; 0.48) $c = -15e^{-4}$ (-21e <sup>-4</sup> ; -9e <sup>-4</sup> )	<b>Monomolecular - R<sup>2</sup> = 0.87</b> $A_u = 17.38$ (13.53; 21.23) $y_0 = -4.93$ (-20.97; 11.1) <sup>4</sup> $r = 0.016$ (15e <sup>-4</sup> ; 300e <sup>-4</sup> )

<sup>(1)</sup>  $y = A_u - (A_u - y_0) \cdot \exp(-rx)$ ; <sup>(2)</sup>  $y = a + bx$ ; <sup>(3)</sup>  $y = A_l + ((A_u - A_l) / (1 + (x / I)^H))$ ; <sup>(4)</sup>  $y = a + bx + cx^2$ .

**Table 3:** Linear and non-linear models adjusted to the response of four scions (mean of two rootstocks) fruit peel color index (y) to the time (x) along 2016 and 2017 harvest season. Parameter estimates are followed by the limits of its 95% confidence interval

	2016	2017
<b>Mexirica do Rio IAC</b>	<b>Second grade model<sup>(1)</sup> - R<sup>2</sup> = 0.97</b> $a = -53.3$ (-68.29; -38.42) $b = 0.54$ (0.28; 0.79) $c = -105e^{-5}$ (-211e <sup>-5</sup> ; 0.6e <sup>-5</sup> )	<b>Logistic<sup>(2)</sup> - R<sup>2</sup> = 0.99</b> $A_l = -15.9$ (-17.16; -16.64) $A_u = 4.58$ (3.41; 5.76) $I = 118.7$ (116.95; 120.42) $H = 12.67$ (10.09; 15.25)
<b>Osvino</b>	<b>First grade model<sup>(3)</sup> - R<sup>2</sup> = 0.89</b> $a = -18.55$ (-20.49; -16.62) $b = 0.2$ (0.17; 0.23)	<b>First grade model - R<sup>2</sup> = 0.9</b> $a = -18.24$ (-20.02; -16.47) $b = 0.21$ (0.18; 0.24)
<b>Satsuma Okitsu</b>	<b>Logistic - R<sup>2</sup> = 0.97</b> $A_l = -13.58$ (-14.51; -12.64) $A_u = -0.11$ (2.42; 2.21) $I = 68.97$ (65.17; 72.76) $H = 9.29$ (5.4; 13.18)	<b>Logistic - R<sup>2</sup> = 0.98</b> $A_l = -14.49$ (-15.83; -13.16) $A_u = 10.19$ (0.4; 19.97) $I = 91.38$ (73.64; 109.11) $H = 4.05$ (2.41; 5.69)
<b>Clemenules</b>	<b>Second grade model - R<sup>2</sup> = 0.98</b> $a = -28.5$ (-36.03; -21.04) $b = 0.14$ (-0.016; 0.31) $c = 7.86e^{-4}$ (-0.49e <sup>-4</sup> ; 16.2e <sup>-4</sup> )	<b>Logistic - R<sup>2</sup> = 0.99</b> $A_l = -17.07$ (-18.28; -15.87) $A_u = 14.3$ (10.7; 17.89) $I = 118.05$ (114.36; 121.74) $H = 7.78$ (6.15; 9.4)

<sup>(1)</sup>  $y = a + bx + cx^2$ ; <sup>(2)</sup>  $y = A_l + ((A_u - A_l) / (1 + (x / I)^H))$ ; <sup>(3)</sup>  $y = a + bx$

In the comparison performed with all scions at same day, CI was significantly higher in both Satsumas than ‘Mexirica do Rio IAC’ and ‘Clemenules’ (Table 1). Furthermore, in 2017, ‘SCS458’ Osvino’ had yellower peel than ‘Satsuma Okitsu’. In addition, ‘Clemenules’ showed more peel maturation precocity than ‘Mexirica do Rio IAC’.

**Discussion**

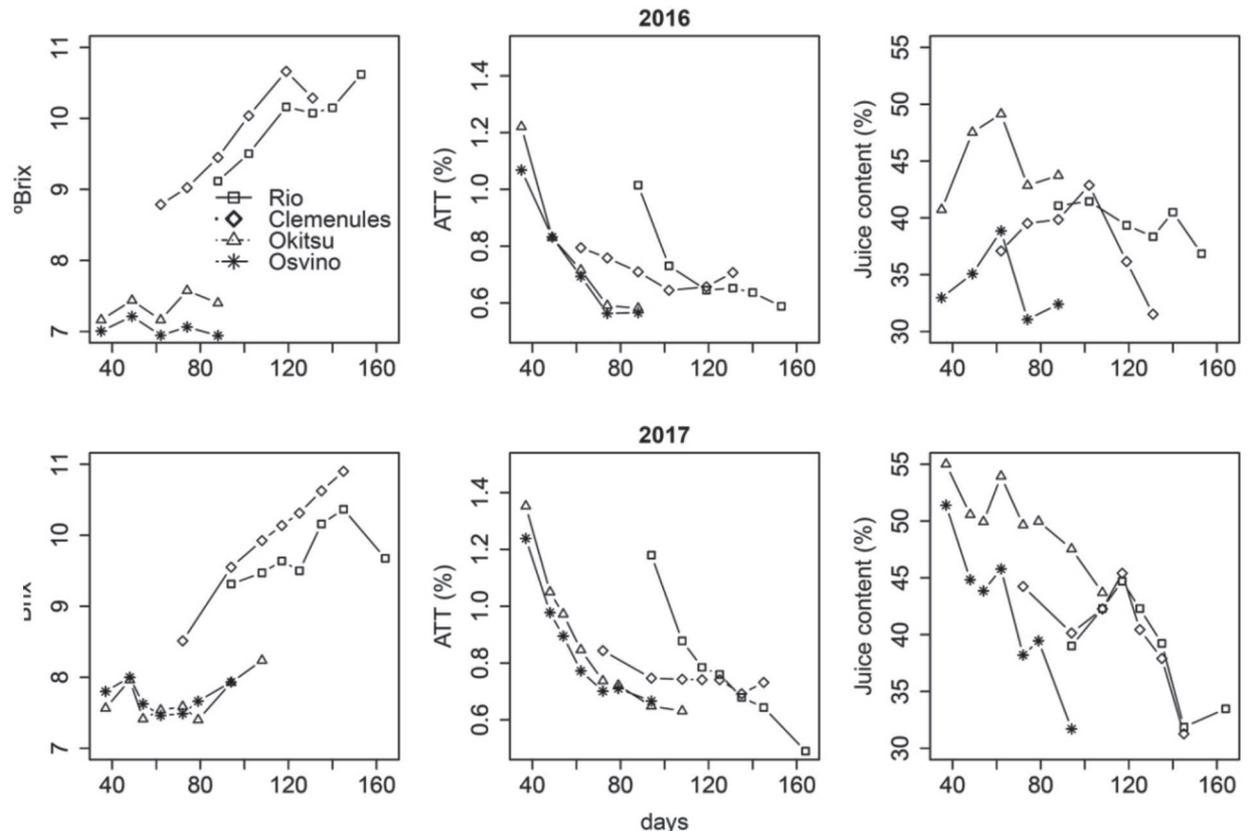
In the range of time considered here, it is possible to state that ‘SCS458 Osvino’ and ‘Satsuma Okitsu’ depend mainly on loss of acidity for reaching commercial maturing. Meanwhile, for ‘Clemenules’ the increase in SS is more important than loss of AT. Growing trend in SS and RI and decreasing in TA are well known. From blooming to end of ripening, SS of *C. sinensis* responded positively and TA negatively to degree-days accumulation in a quadratic pattern (Stenzel *et al.*, 2006), what explain the evolution observed in this work if considered the short period evaluated, which started some months after bloom.

The values of SS measured for ‘Satsuma Okitsu’ are lower compared to observation in Turkey (9.2°Brix) at late September (Yildiz & Kaplankiran, 2018), equivalent to late March in Brazil, and evaluations at March and February in Londrina (Tazima *et al.*, 2013) and Paranavaí (Tazima *et al.*, 2014), Brazil. It is possible that climate differences are

responsible for that discordance, since Londrina and Paranavaí are under hotter climate, what favors SS accumulation.

Harvesting time is difficult to determinate since each market demands a different maturation score. In South Brazil, the minimum RI for harvesting is 8.0 (Koller, 1994). Using the models, it was estimated that ‘SCS458 Osvino’, ‘Satsuma Okitsu’ and ‘Clemenules’ reached juice maturity the 48°, 48° and 44° day in 2016 and 48°, 54° and 55° in 2017, respectively, without any significant difference. Over time, RI of the three tended to keep the same, resulting in absence of difference in evaluations performed around 90-100 days (Table 1). Meanwhile, ‘Mexirica do Rio IAC’ reached RI equal to 8.0 on the 83<sup>rd</sup> and 96<sup>th</sup> days in 2016 and 2017, respectively, which represents 39 to 48 days of delay in relation to the others.

Based on the models, CI of ‘Satsuma Okitsu’ was estimated to be 3.8 to 5 CI-points lower than of ‘SCS458 Osvino’ from 45 to 55 days. Since previous information states ‘Satsuma Okitsu’ is the first mandarin to be harvested in Brazil (Schwarz, 2009), these results qualify ‘SCS458 Osvino’ as the earlier-ripening mandarin in the country, having as main advantage the peel color. Despite Satsumas capacity to reach orange-red coloration by accumulation of carotenoids like monol, diol, diepoxide



**Figure 2:** Temporal evolution of soluble solids (SS) and titrable acidity (TA) in the juice and fruit juice content of four mandarin cultivars in the seasons 2016 and 2017 (mean of two rootstocks). Rio = Mexirica do Rio IAC; Okitsu = Satsuma Okitsu; Osvino = SCS458 Osvino.

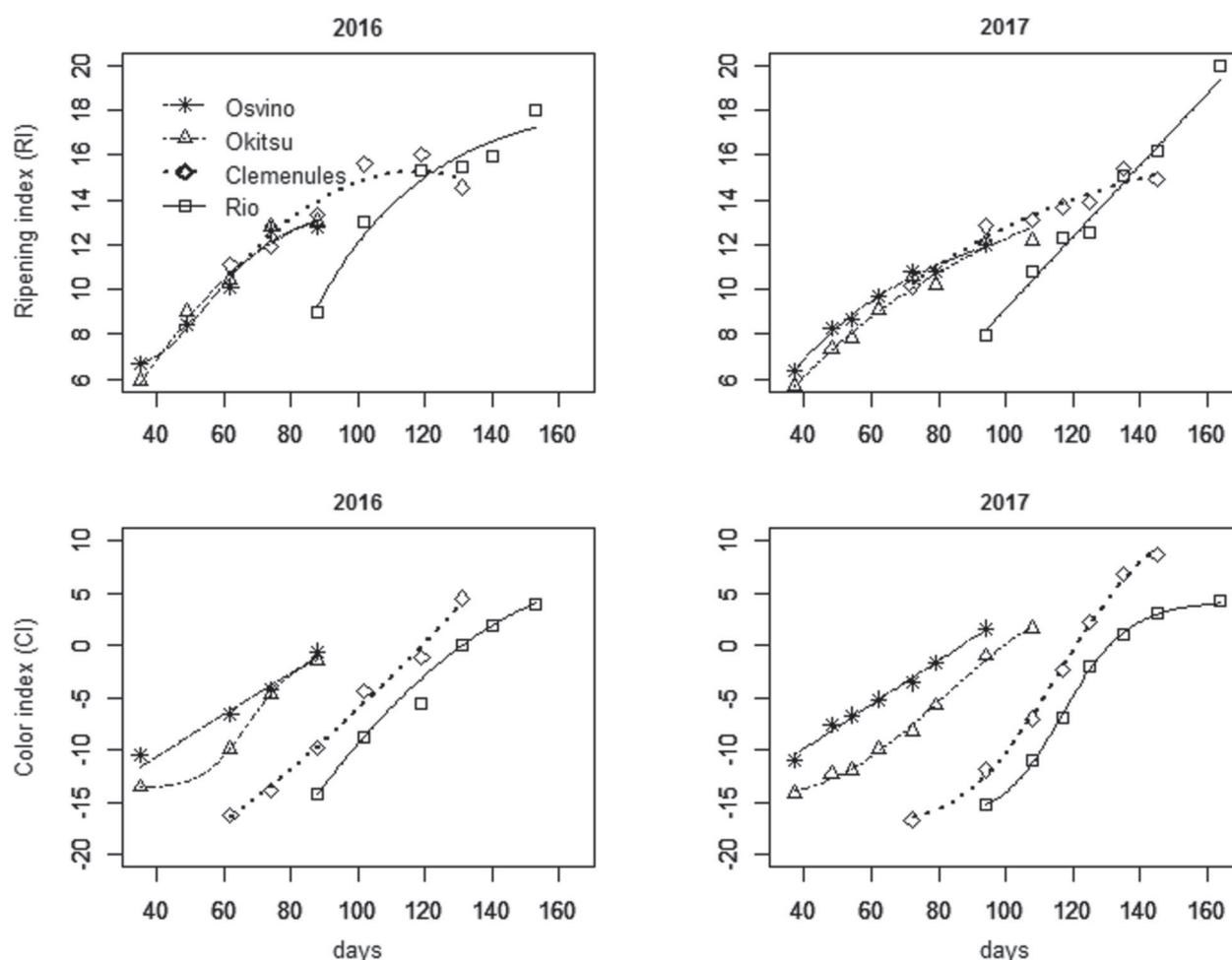
and diol monoepoxide (Daito, 1986), the magnitudes reached by the coordinate  $a$  from the C.I.E.-Lab system are in the range of green, excepting the last evaluation in 2017. It happened in part because the fruit had been exposed to warmer temperatures until the sampling compared to the days ahead (Figure 1), and low temperatures are negatively correlated to  $a$  (Manera *et al.*, 2013).

Some limitations of 'SCS458 Osvino' have to be considered: around 60-80 days its juice content fell under 35%, what is a minimum value for marketing mandarins. Brugnara (2017) observed that 'SCS458 Osvino' produced big size fruits (averaging 163g), what can partially explain the poor juiciness (Sharma *et al.*, 2006). Late harvest of 'Clemenules' and 'Satsuma Okitsu' in Minas Gerais, Brazil, resulted in high granulation (reduced juiciness inside vesicles) incidence (Santos *et al.*, 2010), what agrees with the trend of reduction in juice of all scions studied here.

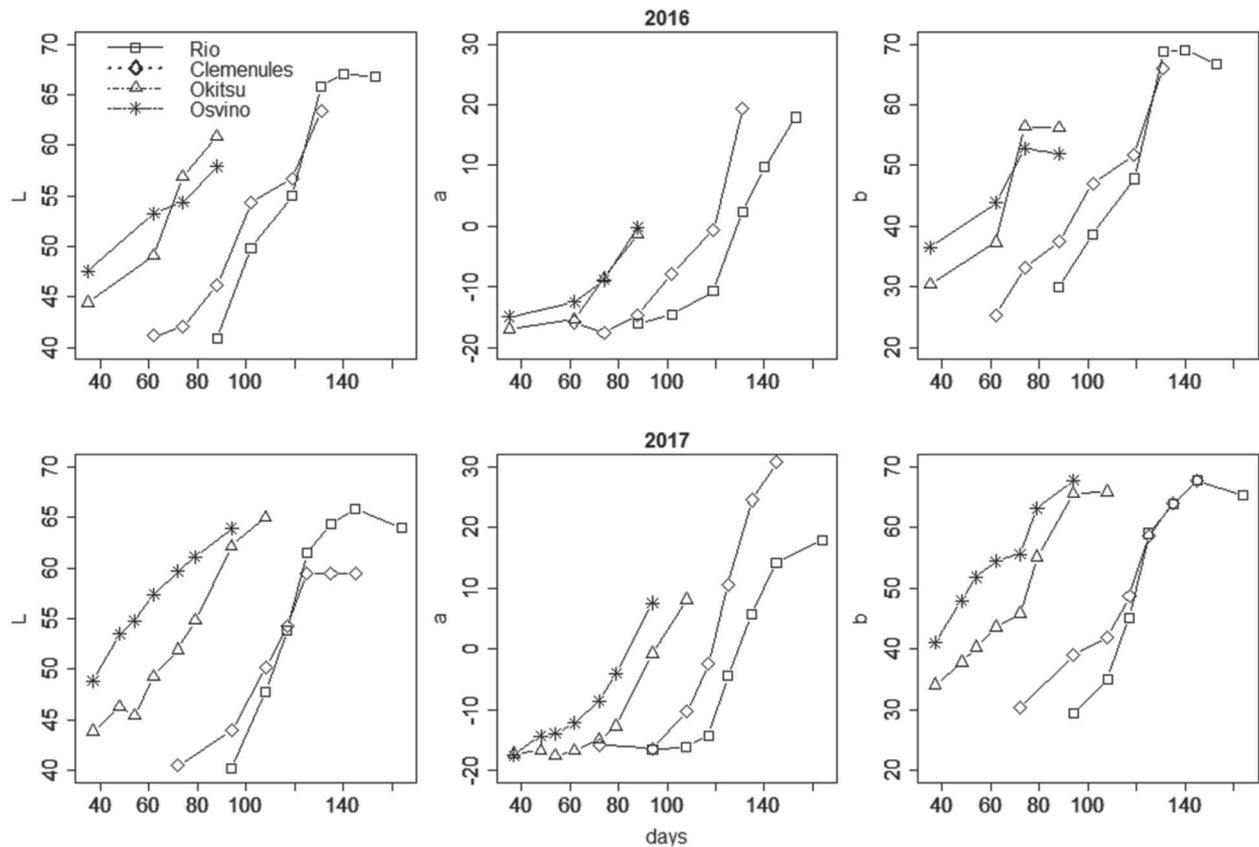
Juice content of 'Satsuma Okitsu' was the highest, what agrees with previous findings (Yildiz &

Kaplankiran, 2018). Means were similar to the observations of Tazima *et al.* (2013), who measured 44 to 47% of juice in fruits harvested in Londrina, in March. The same authors corroborate the present observation on SS, TA and RI.

Regarding RI, 'Clemenules' was similar to the Satsumas at beginning of samplings. The similarity of 'Satsuma Okitsu' and 'Clemenules' was previously reported by Santos *et al.* (2010) at late season (June). However, 'Clemenules' showed higher absolute values of SS and TA, which means its juice is superior in quality besides having same RI. So the limitation to starting to harvest 'Clemenules' relied on its peel color, which turned from green to yellow/orange later compared to the Satsumas. On the other hand, 'Clemenules' had earlier juice and peel maturation compared to 'Mexirica do Rio IAC' and showed the highest SS content. So, it is supposed that, among the scion cultivars tested here, 'Clemenules' juice would be well accepted by the consumer. The values observed in this work for SS and



**Figure 3:** Graphical representation of the models adjusted to the temporal evolution of juice ripening index (RI) and peel color index of four mandarin cultivars in the seasons 2016 and 2017 (mean of two rootstocks). Rio = Mexirica do Rio IAC; Okitsu = Satsuma Okitsu; Osvino = SCS458 Osvino.



**Figure 4:** Temporal evolution of the parameters  $L$ ,  $a$  and  $b$  (C.I.E.-Lab color system) in mandarin peel of four cultivars in the seasons 2016 and 2017 (mean of two rootstocks). Rio = Mexirica do Rio IAC; Okitsu = Satsuma Okitsu; Osvino = SCS458 Osvino.

RI with 'Clemenules' agree with observations from Corrientes, Argentina, and Rosário do Sul, Brazil (Malgarim *et al.*, 2007; Rodriguez *et al.*, 2007).

The cultivar Mexirica do Rio IAC needed more time to reach a same value of RI or CI than the others. However, when compared to the Satsumas it showed higher SS content. 'Mexirica do Rio IAC' surpassed the RI of 8.0 at 96° day in 2017, and in 2016 it had been already over the limit (RI = 8.0) at first sample (88° day). That time, its CI was still in green range (around -15). So, as well as 'Clemenules', harvest beginning for 'Mexirica do Rio IAC' depends on its peel color. However, there is no objective CI to determinate harvesting time. It depends on the consumer preference, which is particular of each country or region.

'Swingle' and 'IAC 387 Carrizo' affected 'Clemenules' juice acidity in a late harvest (RI near 20) in Spain (Legua *et al.*, 2014). With 'Satsuma Okitsu', SS and RI were influenced significantly by those rootstocks (Tazima *et al.*, 2013). Both results disagree with the present findings. Nevertheless, other authors found no difference due to 'Swingle' and 'IAC 387 Carrizo' treatments in SS, TA, RI and juiciness of 'Satsuma Okitsu' (Tazima *et al.*, 2014). The disagreeing observations on juice quality with same

scion and rootstocks cultivars can be due to different environments and management of plants. Rootstocks have different capacities of taking water and nutrients from the soil (Toplu *et al.*, 2012, Hussain *et al.*, 2018) and producing growth regulators (Tworkoski & Fazio, 2016) to supply to the canopy. The interaction of such capacities with the environment results in different responses of fruit quality. Any data on the effect of 'IAC 387 Carrizo' as a rootstock for *C. deliciosa* is available. However, no difference in juice properties was observed when the citrange 'Troyer' was compared to 'Swingle' having 'Montenegrina' (a late maturing *C. deliciosa* cultivar) as scion cultivar (Gonzatto, 2015), what agrees with the present findings.

## CONCLUSION

The cultivars SCS458 Osvino, Satsuma Okitsu and Clemenules are earlier in maturation compared to 'Mexirica do Rio IAC'.

'SCS458 Osvino' is the most precocious in peel maturation.

The rootstocks 'Swingle' and 'IAC 387 Carrizo' do not affect fruit maturation of 'SCS458 Osvino', 'Satsuma Okitsu', 'Clemenules' nor 'Mexirica do Rio IAC'.

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