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Scientific Paper

Postharvest yellow passion fruit harvested in advance at tropical high-altitude regions

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Abstract

Low temperatures near full ripening of fruits bring about unfeasibility of passion fruit cultivation at tropical high-altitude regions. Aiming at defining the possibility of harvesting the fruits in advance, the current research was proposed to assess postharvest-quality of passion fruits at a green-peel phenological stage under influence of treatments with and without ethephon application so that the fruits might be consumed shortly before winter season. For such, soluble acids (SS), titratable acidity (AT), ratio, loss of mass, pulp yield, thickness and color index of peel (ICC) and pulp (ICP), carbon dioxide emissions, and ethylene production were determined herein. The experimental design was completely randomized in factorial scheme with fruits both treated with and without ethylene along with five storage periods. Fruits immersed into ethylene showed peel color 100% yellow after 14 days-time (three days after application of the control treatment). Pulp color, peel thickness, loss of mass and pH did not differ among treatments, as well as AT, SS and ratio evidenced similarities in terms of physiological responses. Yield pulp met the standards required by the industry under the influence of both treatments. As a result, yellow passion fruits might be harvested in advance bereft of any significant detrimental impacts on commercial characteristics in such a way as to promoting its commercialization at marginal regions amenable to the crop.

Keywords: *Passiflora edulis* Sims., quality, ripening.

Pós-colheita de maracujá amarelo colhido antecipadamente em regiões tropicais de altitude

Resumo

As baixas temperaturas próximas a maturação plena dos frutos inviabilizam o cultivo do maracujá em regiões tropicais de altitude. A fim de definir a possibilidade de colheita antecipada, objetivou-se avaliar a qualidade pós-colheita de frutos colhidos antecipadamente (casca verde), com e sem tratamento com ethephon, visando ao aproveitamento dos frutos antes da chegada do inverno. Para tanto, determinou-se sólidos solúveis (SS), pH, acidez titulável (AT), ratio, perda de massa, rendimento de polpa, espessura e índice de cor da casca (ICC) e polpa (ICP), produção de CO2 e etileno. O delineamento experimental foi inteiramente casualizado em esquema fatorial com frutos tratados ou não com etileno e cinco períodos do armazenamento. Frutos imersos em ethephon apresentaram cor da casca 100% amarela após 14 dias (três dias antes do tratamento controle). Cor da polpa, espessura da casca, perda de massa e pH não diferiram entre os tratamentos, bem como AT, SS e ratio apresentaram semelhanças. O rendimento de polpa obedeceu ao nível requerido pela indústria em ambos os casos. Com isto, frutos de maracujá-amarelo podem ser colhidos antecipadamente sem perdas significativas das características comerciais, propiciando sua comercialização em áreas marginais a cultura.

Palavras-chave: *Passiflora edulis* Sims., qualidade, maturação.

Postcosecha de maracuyá amarilla cosechada temprano en regiones tropicales de tierras altas

Resumen

Las bajas temperaturas cercanas a la plena madurez de las frutas hacen que sea inviable cultivar maracuyá en regiones tropicales de altitud. Con el reto de definir la posibilidad de una cosecha temprana,

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el objetivo fue evaluar la calidad poscosecha de las frutas cosechadas temprano (cáscara verde), con y sin tratamiento con ethephon, con el objetivo de utilizar la fruta antes de la llegada del invierno. Para esto, sólidos solubles (SS), pH, atio, acidez titulable (AT), pérdida de masa, rendimiento de pulpa, espesor e índice de color de la cáscara (ICC) y pulpa (ICP), producción de CO2 y etileno. El diseño experimental fue completamente al azar en un esquema factorial con frutas tratadas o no con etileno y cinco períodos de almacenamiento. Las frutas sumergidas en ethephon presentaran un color de piel 100% amarillo después de 14 días (tres días antes del tratamiento de control). El color de la pulpa, el grosor de la cáscara, la pérdida de peso y el pH no difirieron entre los tratamientos, así como la AT, SS y ratio mostraron similitudes. El rendimiento de la pulpa estuvo al nivel requerido por la industria en ambos los casos. Con esto, se puede cosechar los frutos de maracuyá amarillo por adelantado sin una pérdida significativa de características comerciales y proporciando su comercialización en áreas marginales al cultivo.

Palabras clave: *Passiflora edulis* Sims., calidad, maduración.

Introduction

Passion fruit crop (*Passiflora edulis* Sims.), among the fruit species group, turns out to be an excellent alternative since it deals with a commodity that renders yields yet at the first year of cultivation. It garners desirable marketing prices and puts Brazil in the spotlight when it comes to its large area of production (SANTOS et al. 2017, COELHO et al. 2016, POLL et al. 2013).

The fruit is largely consumed at a commercial scale for its pulp possesses a high nutritious value and outstanding organoleptic characteristics (ROTILI et al. 2013, VIANNA-SILVA et al. 2010). Its chemical composition is influenced by maturation stage and harvest time (VIANNA-SILVA et al. 2008). Given the fact that passion fruit is classified to be as climacteric yoked to a mean yield of roughly 7 $nL.g^{-1}.h^{-1}$ from green fruits (WINKLER et al. 2002), harvest might be possible with the fruits still at the green peel-stage.

Yellow passion fruit crop grows well at both tropical and subtropical regions under mean air temperatures ranging from 20 to 32oC, at a relative humidity of approximately 60%, and a photoperiod duration corresponding to over 11 hours (SÁ et al. 2008). Scientific investigations report that winter passion fruit growing season may be harvested with at least 30% yellow skin color bereft of any visible damage in fruit quality (COELHO et al. 2010). This triggers its expansion at marginal sites and takes advantage of the market in such a way as to provide good prices for the growers as a function of commercialization at local specific-markets.

In the light of the problem at issue, the main goal of the current contribution was to assess postharvest quality of passion fruits harvested in advance (at the green peel-stage) with and without ethephon, aiming at making the most of passion fruits shortly before the winter season.

Material and methods

The yellow passion fruits were harvested at the municipality of Ponta Grossa, PR, Brazil, in June 2019 and were selected in compliance with its intense and bright green skin-color. The fruits were divided into two plots comprising five samples related to the periods of storage. One plot was treated with immersion of fruits in a 250 ppm-solution of ethephon and another plot was elected as a control treatment. The fruits were assessed at 0, 7, 10, 14, and 17 days of storage at ambient temperature.

The scrutinized response variables were as follows: soluble solids (SS-°Brix); pH; titratable acidity (TA); weight loss (%), which was obtained by the following expression M_0 - M_1 / M_0 (where M_0 = total weight and M_0 -M_1 = pulp weight); pulp yield (%), being calculated by dividing pulp weight by overall weight of the fruit; peel thickness (mm), defined by four cuts at the equatorial region of the fruit taking equidistant positions for thickness measurements by means of a digital pachymeter. Either skin color or peel color were determined at two equidistant points on the fruits by making use of a Minolta (CR-300) colorimeter under the system L, a* and b*. Both skin color index (SCI) and pulp color index (PCI) were calculated by means of the equation CI = (1.000 x a*)/(L x b*), taking into account that values near -20 represent green color and close to +20 depict red color.

Carbon dioxide and ethylene concentrations were quantified by means of a gaseous chromatography gadget (Trace CG Ultra Violet) with an ionization detector of flames (IDF) along with a column for determination of CO_2 and C_4H_4: PoraPak at 170 °C. Crop samples containing roughly 400 passion fruits throughout the periods of 0, 7, 10, 14, and 17 days were placed in recipients of 500mL,

hermetically shut for two hours. In so far as such a span of time went by, 1mL of the gaseous atmosphere was collected with the help of a hypodermic syringe for the assessments of CO_2 and ethylene, with the outcomes being expressed in $nL.g^{-1}.h^{-1}$.

The experimental design for statistical analyses was a completely randomized design with two factors under scrutiny: first factor refers to passion fruits with and without ethephon applications; second factor comprises five storage times arranged in a factorial scheme (2 x 5) with three replications and an experimental plot encompassing six fruits. The obtained results were subjected to the Analysis of Variance (ANOVA) with the test F application in conjunction with Tukey test at 5% reliability, making use of the SAS 8.2 computer statistical program.

Results and discussion

SCI varied from -9.6 at the harvest to -2 after 17 days of storage at an ambient temperature for both treatments (Figure 1A), highlighting the change of colors from green to yellow.

The greatest discrepancy owing to application of the treatments might be noticed on the fruits treated with ethylene, although no significant differences were actually observed among times of storage (Figure 1A). SCI thresholds equivalent to -2 after 7 days represented fruits with 75% intense

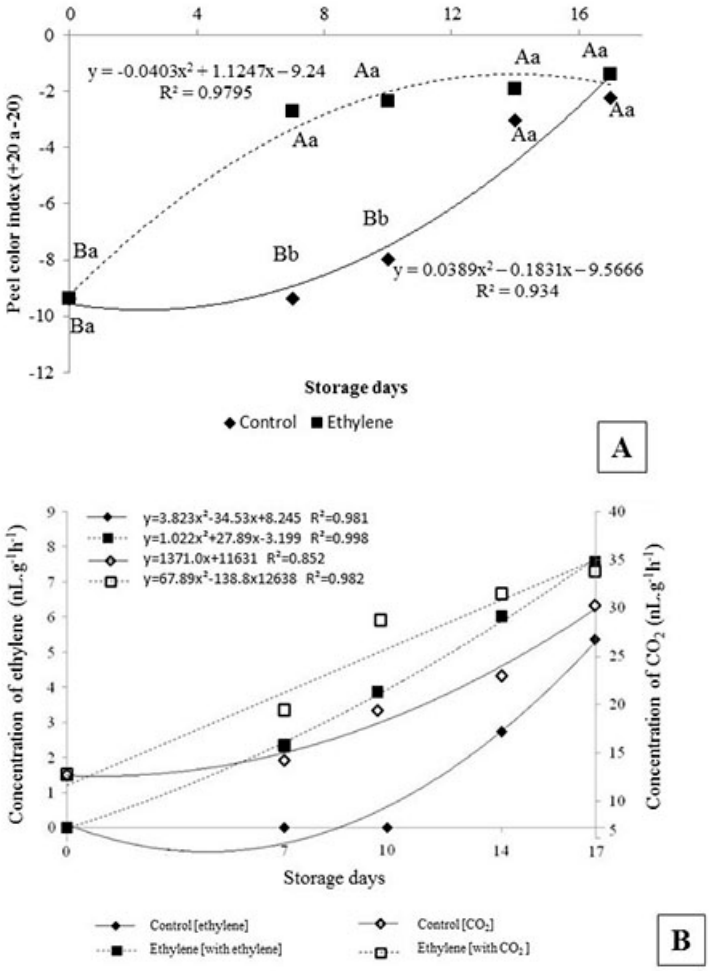

Figure 1. Peel color index of fruits (A) and concentrations of CO_2 and ethylene in fruits of passion fruit with and without ethylene treatment stored at ambient temperature (B). Distinct capital letters among days of storage and also different small letters among treatments indicate significant statistical differences by means of the Tukey test at 5% reliability.

yellow skin-color, whereas from 14 days onwards all fruits depicted an 100% intense yellow skin-color. With regards to the fruits under control treatment, SCI change was gradual and slow having started at only after 10 days with about 50% yellow skin-color and then reaching 100% yellow skin-color after 17 days at ambient temperature (Figure 1A).

Vianna-Silva et al. (2010) determined that skin color evolves throughout the storage, evidencing a trend of change from green to yellow after nine days of storage irrespective of the harvest date, as well as maintenance of the fruits in plant procrastinates such a loss of the green color in conjunction with the yellowish of the fruits.

These outcomes confirm ethylene production and also increases in respiratory rates of the fruits at the same period of time (Figure 1B). The change of skin color of the fruits of passion fruit takes place as a function of chlorophyll degradation along with synthesis of carotenoids, which are responsible for the yellow and orange colors of the fruits (Santos et al. 2010). Either degradation or synthesis of pigments are to be conditioned by ethylene concentrations in the fruits, whose synthesis itself is stimulated by detachment of the fruit from the plant (VIANNA-SILVA et al., 2010). By the results obtained herein we came up with the conclusion that treatments with ethylene accelerate skin-color changes (Figure 1A).

Experimental data reported on PCI, TA and pH did not show significant differences between factors under scrutiny, such as treatment and time of storage from passion fruits recently harvested (Table 1). The positive values of PCI refer to an intense orange color incrusted in the pulp of the fruits, demonstrating that such a particular coloration comes to being quite representative to indicate that passion fruit reached physiological maturity at harvest, inspite of the skin color of the fruit remains green. According to Marchi et al. (2000), evolution of skin color is not related to pulp color, which in turn remains constant in fruits of yellow passion fruit with 30% yellow skin-color throughout the crop growing seasons of April, May and June. The outcomes reveal that even with a green skin-color the pulp of the fruits might already have reached physiological maturity.

By comparing TA thresholds achieved under control treatment to passion fruit plants treated with ethylene after 7 days of application (6.57 and 5.09%, respectively) as opposed to those obtained after 17 days of application (2.48 and 1.49%, respectively), it is possible to notice that there is a consistent decrease in organic acids of fruit juice under the influence of both treatments (Table 1). Several studies conducted with yellow passion fruit corroborate the content of TA found in our research, whose values reported in the literature ranged from 6.46 - 7.24% (ABREU et al. 2009) to 3.91 – 4.68% (MARCHI et al. 2000). Organic acids are reduced with maturation of the fruit because such components come to oxidation and get to be converted into sugars to be utilized in the respiration process as a source of energy (AMARO and MONTEIRO, 2001). High acidity in the pulp turns out to be an important characteristic within the processing of juice since it promotes its conservation (VIANNA-SILVA et al. 2008, ABREU et al., 2009).

Table 1. Mean data of pulp color index (PCI), Titrable Acidity (TA%) and pH of passion fruits treated and non-treated with ethylene under storage at ambient temperature.

Days of Storage	PCI		TA (%)		pH	
	Control	Ethylene	Control	Ethylene	Control	Ethylene
0	3,95		5,63		2,93	
7	4,02 Aa	3,07 Ab	6,57 Aa	5,09 Ab	3,09 A	3,17 A
10	3,83 Aa	2,86 Ab	4,99 Ba	4,03 ABb	3,04 A	3,10 A
14	3,34 Aa	2,80 Ab	4,09 Ba	3,07 Bb	2,95 A	3,04 A
17	3,29 Aa	2,80 Ab	2,48 Ca	1,49 Cb	2,94 A	2,12 A

Different capital letters on the columns among days of storage along with different small letters on the lines among treatments are inducive to statistical differences by the Tukey test at 5% reliability.

In light of mean values, pH fluctuated between 3.00 and 3.06 being in accordance with Marchi et al. (2000) and pointing out no significant discrepancies among treatments throughout the storage. Similarly, Coelho et al. (2010) did not find any consistent effect of treatments on mean values of pH during storage, reaching therefore the mark of 2.92. Conversely, Campos et al. (2007) obtained pH values higher than those reported in the current research, ranging from 3.2 to 3.4. Such a condition reveals that

the lower pH the higher acidity concentration in the juice of the fruits will be.

Soluble solids (SS) values varied from 12.24 to 14.26 °Brix under control treatment, as well as from 11.78 to 13.90 °Brix for fruits treated with ethylene with a slight reduction in SS at 17 days of storage (Figure 2A). The usual contents of SS for yellow passion fruit reported in the literature range from 12.23 to 14.67 °Brix (MARCHI et al., 2000, CAVICHIOLI et al., 2011, BORGES et al., 2003). SS concentration turns out to be an indicative parameter of quality of the fruits destined to industrialization, highlighting commercial preferences ascribed for fruits with SS concentrations higher than 14.5 °Brix (COELHO et al., 2010, CAVICHIOLI et al., 2011).

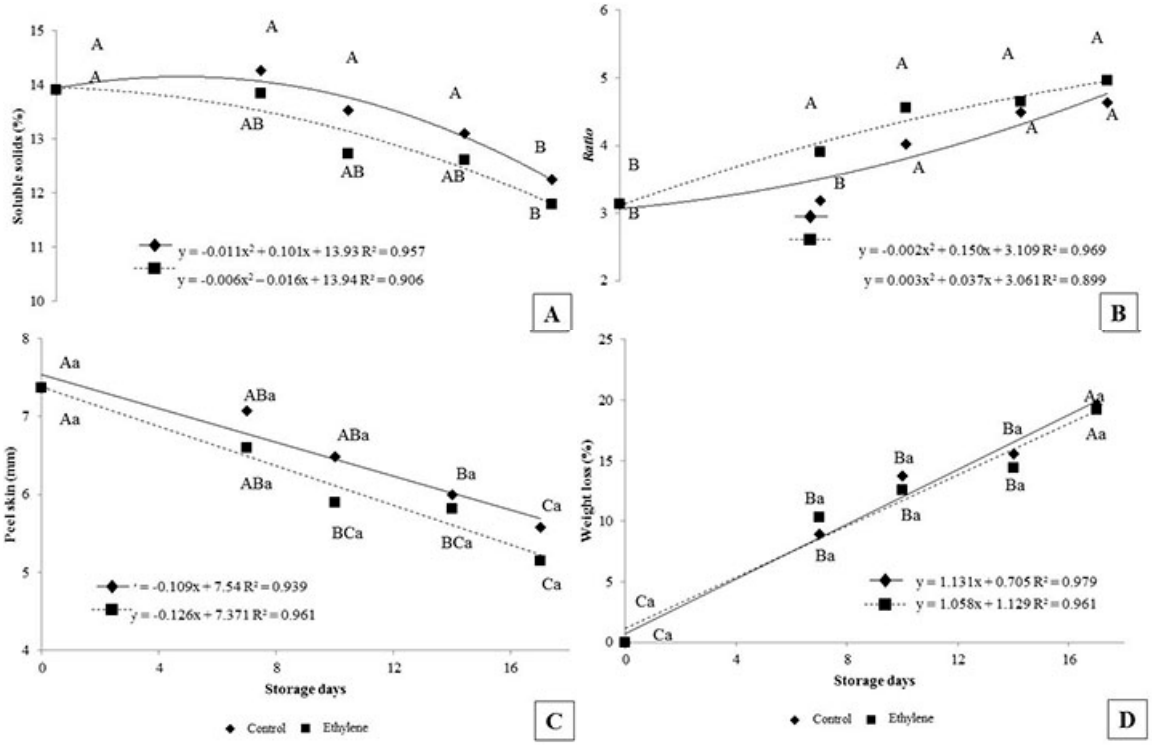

Figure 2. (A): Soluble solids concentration (°Brix), (B): *Ratio*, (C): Peel skin (mm), (D): Weight loss of passion fruits treated and non-treated with ethylene under storage at ambient temperature. Different capital letters among days of storage depict significant statistical differences by the Tukey test at 5% reliability.

Ratio, given by SS/TA quotient, oscillated from 3.1 to 4.9 (Figure 2B). By the time of harvest and shortly after 7 days of storage significant differences due to high values of TA were detected, leading to outcomes that resonate with the findings of Cavichioli et al. (2011) and Borges et al. (2003).

By the end of a period of 17 days of storage, we observed a rise in ratio as a function of a direct influence of reductions in TA concentrations (Figure 2A). *Ratio* remarkably expresses maturation physiological stage of the fruits during storage, since the balance between SS and acidity indicates fruit flavor and might vary considerably in compliance with harvest moment. Throughout maturation ratio tends to increase mainly as a result of acidity depletions (VIANNA-SILVA et al. 2008).

Mean values for peel thickness did not culminate in significant differences among treatments and, therefore, evidenced drops of 7.4 mm at harvest and of 5.1 mm after 17 days of storage (Figure 2C). The results reveal that fruit skin was a target of a conspicuous reduction in peel thickness throughout the storage. Vianna-Silva et al. (2008) and Vianna-Silva et al. (2010) obtained similar physiological responses related to peel thickness mean depletions ranging from 8.2 to 4.9 mm.

Throughout the period of storage, the fruits of passion fruit presented a mean weight loss varying from 9.5 to 19.3% (Figure 2D). For some fruits, a fresh weight loss within the magnitude of 3 to 6% is sufficient to cause shriveling and considerable declines on fruit quality (CHITARRA and CHITARRA 2005). In our study such a peel wrinkling was found only after 10 days of storage for both treatments with no statistical discrepancies promoted by the influence of treatments.

The pulp yield incremented throughout the period of 17 days of storage for both treatments (Figure 3). Concerning the fruits treated with ethylene, such fruits presented a lower variation in yield throughout the storage. The significant increment of the pulp yield found herein coincides with the reduction in peel thickness under scrutiny and also resonates with the findings of Vianna-Silva et al. (2008) e Vianna-Silva et al. (2010).

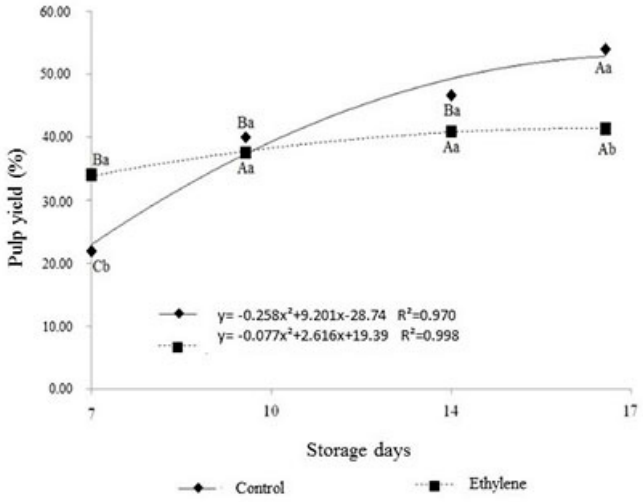

Figure 3. Pulp yield (%) of fruits of passion fruit treated or non-treated with ethylene under storage conditions at ambient temperature. Different capital letters among days of storage along with different small letters among treatments show significant statistical differences by the Tukey test at 5% reliability.

Aular et al. (2000) reported pulp yields outcomes corresponding to 35.7 and 44% for mature fruits, whose values were to be rather close to those ones found in our work (Figure 3). Figure 3 illustrates that pulp yields of 41 and 50% after a period of 17 days of storage refer to fruits treated with ethylene and control treatment, respectively, surpassing then the minimal threshold strongly recommended as a standard for industrial processing (33%) (VIANNA-SILVA et al. 2008).

Conclusions

Fruits of passion fruit crop harvested at a green skin-color stage, but in light of a quintessential cultivar pulp color show the same quality characteristics of mature fruits.

The application of ethylene to the fruits did not demonstrate any outstanding effects on pulp maturation changes throughout the storage, but rather a rapid maturation of peel after seven days-treatment.

It is possible to cultivate passion fruits at marginal areas belonging to high-altitude lands of tropical regions, as long as fruits of passion fruit might be stored within quality standards required by the industries.

References

ABREU, S. P. M.; PEIXOTO, J. R.; JUNQUEIRA, N. T. V.; SOUSA, M. A. F. Características físico-químicas de cinco Genótipos de maracujazeiro-azedo cultivados no Distrito Federal. **Revista Brasileira de Fruticultura**, v. 31, n. 2, p. 487-491, 2009.

AMARO, A. P.; MONTEIRO, M. Rendimento de extração da polpa e características fisico-químicas do maracujá-amarelo (*Passiflora edulis* F. *Flavicarpa Sims*. Deg.) produzido por cultivo orgânico e convencional em relação à cor da casca. **Alimentos e Nutrição**, v. 12, p. 171-184, 2001.

AULAR, J.; RUGGIERO, C.; DURIGAN, J. F. Influência da idade na colheita sobre as características dos frutos e do suco de maracujá-amarelo. **Revista Brasileira de Fruticultura**, Jaboticabal, v.22, p.6-8, 2000.

BORGES, A. L.; RODRIGUES, M. G. V.; LIMA, A. A.; ALMEIDA, I. E.; CALDAS, R. C. Produtividade e qualidade de maracujá-amarelo irrigado, adubado com nitrogênio e potássio. **Revista Brasileira de Fruticultura**, v. 25, n. 2, p. 259-262, 2003.

CAMPOS, V. B.; CAVALCANTE, L. F.; DANTAS, T. A. G.; MOTA, J. K. M.; RODRIGUES, A. C.; DINIZ, A. A. Caracterização física e química de frutos de maracujazeiro-amarelo sob adubação potássica, biofertilizante e cobertura morta. **Revista Brasileira de Produtos Agroindustriais**, v.9, n.1, p.59-71, 2007.

CAVICHIOLI, J. C.; CORRÊA, L. S.; BOLIANI, A. C.; SANTOS, P. C. Características físicas e químicas de frutos de maracujazeiro-amarelo enxertado em três porta-enxertos. **Revista Brasileira de Fruticultura**, v. 33, n. 3, p. 905-914, 2011.

CHITARRA, M. I. F.; CHITARRA, A. B. **Pós-Colheita de frutas e hortaliças: fisiologia e manuseio**. 2º ed. Lavras: UFLA, p. 783, 2005.

COELHO, A. A.; CENCI, S. A.; RESENDE, E. D. Qualidade do suco de maracujá-amarelo em diferentes pontos de colheita e após o amadurecimento. **Ciência e Agrotecnologia**, v. 34, n. 3, p. 722-729, 2010.

COELHO, E.M.; AZÊVEDO, L.C.; UMSZA-GUEZ, M.A. Fruto do maracujá: importância econômica e industrial, produção, subprodutos e prospecção tecnológica. **Cadernos de Prospecção**, v.9, n.3, p.323-336, 2016.

MARCHI, R.; MONTEIRO, M.; BENATO, E.A.; SILVA, C.A.R. Uso da cor da casca como indicador de qualidade do maracujá amarelo (*Passiflora Edulis Sims*. *F. Flavicarpa Deg.*) destinado à Industrialização. **Ciência e Tecnologia de Alimentos**, v. 20, n.3, p. 381-387, 2000.

POLL, H.; KIST, B. B.; SANTOS, C. E.; REETZ, E. R.; CARVALHO, C.; SILVEIRA, D. N. **Anuário Brasileiro da Fruticultura.** Santa Cruz do Sul: Editora Gazeta Santa Cruz, p. 136, 2013. ISSN: 1808-4931.

ROTILI, M.C.C.; COUTRO, S.; CELANT, V.M.; VORPAGE, J.A.; BARP, F.K.; SALIBE, A.B.; BRAGA, G.C. Composição, atividade antioxidante e qualidade do maracujá amarelo durante armazenamento. **Semina: Ciências Agrárias**, v. 34, n. 1, p.227-240, 2013.

SÁ, C. R. L.; SILVA, E. O.; TERAO, D.; SARAIVA, A.C.M. Métodos de controle do etileno na qualidade e conservação pós-colheita de frutas. **Embrapa Agroindústria Tropical**, Fortaleza, 1ª ed., p. 36, 2008. ISSN 1677-1915.

SANTOS, D.; MATAROZZO, P.H.M.; SILVA, D.F.P.; SIQUEIRA, D.L.; SANTOS, D.C.M.; LUCENA, C. C. Caracterização físico-química de frutos cítricos apirênicos produzidos em Viçosa, Minas Gerais. **Revista Ceres**, v. 57, n.3, p. 393-400, 2010.

SANTOS, V.A.; RAMOS, J.D.; LAREDO, R.R.; SILVA, F.O.R.; CHAGAS, E.A.; PASQUAL, M. Produção e qualidade de frutos de maracujazeiro-amarelo provenientes do cultivo com mudas em diferentes idades. **Revista de Ciências Agroveterinárias**, v.16, n.1, p.33-40, 2017.

VIANNA-SILVA, T.; LIMA, R. V.; AZEVEDO, I. G.; ROSA, R. C. C.; SOUZA, M. S.; OLIVEIRA, J. G. Determinação da maturidade fisiológica de frutos de maracujazeiro-amarelo colhidos na região norte do estado do Rio de Janeiro, Brasil. **Revista Brasileira de Fruticultura**, v. 32, n. 1, p. 057-066, 2010.

VIANNA-SILVA, T.; RESENDE, E. D.; VIANA, A. P.; PEREIRA, S. M. F.; CARLOS, L. A.; VITORAZI, L. Qualidade do suco de maracujá-amarelo em diferentes épocas de colheita. **Ciência e Tecnologia de Alimentos**, v. 28, n. 3, p. 545-550, 2008.

WINKLER, L. M.; QUOIRIN, M.; AYUB, R. A.; ROMBALDI, C.; SILVA, J. Produção de etileno e atividade da enzima ACCoxidase em frutos de maracujá-amarelo (**Passiflora edulis f. Flavicarpa Deg.**). **Revista Brasileira de Fruticultura**, v. 24, n. 3, p. 057-066, 2002.