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Fruit Characteristics of Eighteen Orange Cultivars[1]

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ABSTRACT

Several characteristics related to fruit quality, such as length, width, length/width relation, mass, soluble solids (SS), titratable acidity (TA), SS/TA ratio and technological index (TI) were evaluated in eighteen orange cultivars. A completely randomized design with eighteen treatments and four replications was adopted. Each treatment was represented by one cultivar. Results were submitted to variance analyses and Tukey test at 0.01 probability error. The results indicated that there was statistical difference among orange cultivars for all variables studied. Tarocco A cultivar detached with the largest and the most weighted fruits, so this cultivar has potential for fresh fruit market. 'João Nunes' presented the highest SS/TA ratio and 'Westin' and 'Jaffa' the highest TI. In a general form, orange cultivars presented high variability among them in relation to fruit quality characteristics.

Key words: *Citrus sinensis,* cultivar selection, fruit technology.

RESUMO

Várias características relacionadas com a qualidade de frutos como comprimento, largura, relação comprimento/largura, massa, sólidos solúveis (SS), acidez titulável (AT), 'ratio' SS/AT e índice tecnológico foram avaliadas em dezoito cultivares de laranja. Adotou-se delineamento inteiramente casualizado com dezoito tratamentos e quatro repetições. Cada tratamento foi representado por um cultivar. Os resultados foram submetidos à análise de variância e ao teste de Tukey à 1% de probabilidade. Os resultados indicaram que houve diferença estatística entre os cultivares de laranja para todas as variáveis estudadas. O cultivar Tarocco A destacou-se com os maiores e mais pesados frutos, portanto este cultivar apresenta potencial para o comércio de fruta fresca. 'João Nunes' apresentou o maior ratio SS/AT e 'Westin' e 'Jaffa' o mais elevado IT. De uma forma geral, os cultivares de laranja demonstraram alta variabilidade entre si em ração à qualidade dos frutos.

Palavras-chave: *Citrus sinensis,* seleção de cultivares, tecnologia de frutos.

1 - INTRODUCTION

Citriculture is a relevant segment of the world economy with more than 80 producer countries that together registered in 2005 a production of almost 60 millions tons. Actually, Brazil is the main world producer of oranges, followed by United States of America, Mexico, India and Spain (FAO, 2006).

Great part of the Brazilian production of oranges is concentrated in São Paulo State, which constitutes the main orange cultivation region of the world. Additionally, the citriculture in São Paulo State is composed basically by four cultivars (Hamlin, Natal, Pera and Valencia), fact that, consequently, promotes the production concentration during part of year and increases the risk of diseases incidence as *greening*, a bacterial disease that can become the most difficult obstacle of citriculture in XXI century.

The study of new orange cultivars in relation to fruit quality is important to obtain new cultivars with economic potential to

diversify orange crops in São Paulo State. In this way, Negri (1996) detaches Rubi, Westin and Pineapple cultivars with good technological quality of fruits for industry, aiming also the expansion of time harvest.

Physical and chemical parameters constitute important variables to evaluate the maturation and quality of fruits (Washowicz and Carvalho, 1992). In this sense, soluble solids (SS), titratable acidity (TA), technological index (kg of soluble solids in an orange box of 40.8kg) and, specially, SS/TA ratio due to orange harvest be done when fruits reach ratio 12, are efficient parameters for selection of new orange cultivars.

The objective of this study was to establish a physical and chemical characterization of eighteen orange cultivars fruits in Bebedouro County, São Paulo State, Brazil.

2 - MATERIAL AND METHODS

The study was conducted using fruits of 18 (eighteen) sweet orange cultivars released from Estação Experimental de Citricultura de Bebedouro (EECB), São Paulo State, Brazil. The orange cultivars were, as follows: Oliverlands, Torregrosa, Finike, Hamlin, Kawata, Cadenera, Majorca, João Nunes e Westin e Jaffa, Moro, Sanguinea, Biondo, Pineapple, Homosassa, Early Oblong, Tarocco A and Rubi. All plants, grafted in 'Swingle', were planted in 1990 in an Oxisol of medium texture (Andriolli et al., 1994). During fruit maturation, there was low precipitation in June (4.3 mm) but the rain was well distributed in months, reaching 531.5 mm. In relation to air temperature, the lowest (12.6ºC) was registered in July and the highest (33.6ºC) in September.

Treatments were distributed in a completely randomized design with four replications. Each treatment was represented by one cultivar.

Fruits of orange cultivars were harvested at full maturity, from external and median portion of the canopy, at an average height of 1.5m, distributed in samples of 10 fruits each one, and conduced to the Laboratory of Horticultural Products.

The methods used in physical and chemical analyses included:

1. Physical analyses

Length and width of fruits: These measures were obtained with a millimetred ruler and expressed in cm.

Fruit mass: Mass was measured using a Sartorious brand precision balance (0.01 g precision), expressed in g.

2. Chemical analyses (According to Instituto Adolfo Lutz, 1976)

Titratable acidity (TA): 20 gram of fruit juice was taken from each orange cultivar and brought to a final volume of 100 mL by adding distilled water. A 20 mL sample was taken from the mixture and three to four drops of phthalein was used as indicator. This suspension was titrated with 0.1 NaOH. The results were expressed in terms of percentage.

Soluble solids (SS): SS expressed as ºBrix, were measured with an digital 'Abbe refractometer'.

Additionally were calculated the following indexes:

* SS/TA ratio: After chemical analysis, the relation between soluble solids and tritatable acidity was calculated.

* Juice percentage: relation between juice and fruit mass.

* Technological index: Obtained through equation below explained and expressed in kg of SS/box of orange.

$$T.\ I. = \frac{\text{juice percentage} \times SS \times 40.8}{10000}$$

Where: SS: soluble solids (ºBrix); 40.8: standard weight of orange harvest box.

* Fruit format: through relation between length and width of fruits.

Statistical analyses included analysis of variance (ANOVA) and Tukey test to mean separation of orange cultivars using Statistica 6.0 software (Ferreira, 2000). Terms were considered significant at $P<0.01$.

3 – RESULTS AND DISCUSSION

There was significant differences ($P<0.01$) among orange cultivars for all fruit variables studied.

3.1 Physical characteristics (Table 1)

'Tarocco A' presented the large fruits in length, but not significantly different to

'Homosassa', as also identified among João Nunes, Kawatta, Cadenera and Mayorca cultivars that presented the lowest length. Hamlin cultivar presented a 7.13cm average, so up to 7.07cm reported by Domingues et al. (2003). On the other hand, Donadio et al. (1995) obtained 6.81 cm for João Nunes, that is compatible with this study.

Width of fruits ranged from 6.73 cm ('Cadenera') to 8.0 cm ('Tarocco A'), this last one with statistical superiority to others cultivars. Among all orange cultivars studied, 13 presented fruit width higher than 7.0cm, that classifies these fruits as large according to Viégas (1991) and shows the potential for consumption as fresh fruit. Average results of 'Hamlin' and 'Westin' are above 6.4 and 6.5cm, respectively reported by Domingues et al. (2003).

Orange cultivars with large fruits present the possibility of consumption as fresh or processed fruit if good quality in relation to chemical characteristics is observed. This is important for farmers to have another option of market for fruit and obtain higher revenues.

By a general form, the analysis of these parameters (length and width) shows that fruits have larger length than width, except Rubi, Pineapple, Biondo, Sanguinea and Westin, thus in agreement with Domingues et al. (2003) for 'Westin' only. Whether length/width relation is around 1, fruits have spherical format; in addition if this value is superior to 1.05, fruits are moderately oblong, as observed in Tarocco A and Homosassa orange cultivars. The average value of 'Hamlin' (1.01) is above 0.98 indicated by Donadio et al. (1995) and close to 1.01 of Domingues et al. (2003), that also obtained 0.96 for 'Westin'.

The fruits of 'Tarocco A' presented the highest individual average mass (237.77g) followed by 'Pineapple' (208.8g), 'Biondo' (205.23g) and 'Finike' (201.20g), while 'João Nunes' and 'Mayorca' presented as the lowest. Fruit mass of Hamlin cultivar was very high in comparison to results quoted in the literature as 133.2g (Domingues et al.,2003) and 130g (Hodgson, 1967). 'João Nunes' presented fruit mass compatible to Donadio et al. (1999) data and 'Rubi' fruits are above 172g indicated by Figueiredo (1991).

Table 1. Average values of fruit physical characteristics (length, width, length/width and mass) of eighteen sweet orange cultivars. EECB, Bebedouro-SP, 2005.

Cultivar	Length	Width	Length/Width	Mass
	cm			g
Oliverlands	7.00 bc	7.00 b	1.00 cde	177.40 b
Torregrosa	7.27 bc	7.17 b	1.01 bcde	194.83 ab
Finike	7.23 bc	7.13 b	1.01 bcde	201.20 ab
Hamlin	7.13 bc	7.00 b	1.02 bcde	184.80 ab
Kawata	6.93 c	6.83 b	1.01 bcde	177.17 b
Cadenera	6.93 c	6.73 b	1.03 abc	182.93 b
Mayorca	6.93 c	6.83 b	1.01 bcde	174.53 b
João Nunes	6.86 c	6.83 b	1.01 cde	168.33 b
Westin	7.07 bc	7.10 b	0.99 cde	192.93 ab
Jaffa	7.30 bc	7.13 b	1.02 abcd	174.00 b
Moro	7.43 bc	7.00 b	1.06 ab	184.33 ab
Sanguinea	7.17 bc	7.33 b	0.98 de	205.23 ab
Biondo	7.27 bc	7.30 b	0.99 cde	208.77 ab
Pineapple	7.00 bc	7.13 b	0.98 cde	208.80 ab
Homosassa	7.57 ab	7.07 b	1.07 a	195.90 ab
Early Oblong	7.10 bc	6.97 b	1.02 bcde	183.73 ab
Tarocco A	8.17 a	8.00 a	1.02 abcd	237.77 a
Rubi	7.03 bc	7.27 b	0.97 e	190.67 ab
S.D.	2.76	2.81	1.64	9.29

Averages followed by the same letter in columns do not differ among them by Tukey test at 0.01 probability error. S.D. = standard deviation.

3.2 Chemical characteristics (Table 2)

As can be seen in Table 2, expressive differences of soluble solids (SS, expressed as ºBrix) among orange cultivars were registered. Hamlin cultivar had the highest SS (13.6ºBrix) followed by 'Mayorca' and 'Westin'. Additionally, Hamlin results are higher than

those reported by Hodgson (1967), Di Giorgi et al. (1990) and Nonino (1995); 'Westin' results showed superior to Figueiredo (1991) values; SS of 'Tarocco A', 'Jaffa', 'Oliverlands', 'Kawatta' and 'Mayorca' are above results of Donadio et al. (1999).

Titratable acidity (TA) was the lowest in fruits of 'João Nunes' and 'Westin', while 'Finike and 'Biondo' presented the highest values. The low values of TA observed in 'João Nunes' and 'Westin' fruits are below the minimum recommended by Steger (1990), i.e., range between 0.75 and 1.0% for industry of concentrated juice. 'Hamlin' TA is below literature results as Hodgson (1967), Nonino (1995), Domingues et al. (2003) and Donadio et al. (1999) that registered 0.96, 0.75, 0.98 and 0.74%, respectively. In comparison to the same literature, 'Westin' presented the same tendency of 'Hamlin', before detailed. 'Homosassa' presented a TA expressively below TA registered in Florida by Hodgson (1967).

In comparison to 'Pera' cultivar, only 'Finike', 'Cadenera', 'Biondo' and 'Early Oblong' are above 0.91% average reported by Blumer et al. (2002).

The SS and TA characteristics, individually, can represent a false indicative of fruit flavour, while the ratio SS/AT is considered a practical form. This ratio is function of equilibrium degree between sugars and organic acids in fruits and, in some fruitful, is adopted as an indicator of fruit maturation and harvest time, as sweet orange. Thus, sweet orange cultivars that reach ratio 12 [required for harvest, as indicated by Viégas (1991)] later should de harvested later and extend the period of harvest in São Paulo State.

According to Table 2, 'João Nunes', 'Westin' and 'Hamlin' presented the highest SS/AT ratio and 'Early Oblong', 'Biondo', 'Finike' and 'Torregrosa' the lowest. 'Westin' ratio (19.32) is above averages indicated by Domingues et al. (2003); as also observed for 'Rubi' in relation to Figueiredo (1991) conclusion. Is important to detach the period of the year when these measurements were registered by each author and the climate of the region in relation to air temperature and precipitation, because these values interfere chemical characteristics of fruits, and consequently maturation time.

In fact, orange fruit quality, independent of cultivar, depends on scion (Bordignon et al., 2003), mineral nutrition (Storey & Treeby, 2002) and, the main factor, climate as concluded Reuther (1973), Holand et al. (2002) and Volpe et al. (2002).

Juice percentages, in general, were low and above results quoted in the literature that can be justified by air climate during fruit development. In this sense, Araújo (1976) assures that juice percentage is influenced by air climate factors as temperature, luminosity and precipitation. In study about orange cultivars, Domingues et al. (2003) obtained 46.5% for 'Hamlin'. 'Westin' average (53.8%) was lower than Donadio et al. (1995) results; 'Pineapple' juice percentage was 17.4% and 19.7 % lower than averages registered by Nonino (1995) and Donadio et al. (1999), respectively.

It's important to affirm that all orange cultivars studied presented juice percentage up to the minimum acceptable for orange consumption as fresh fruit (35%), according to Jones et al. (1965).

The technological index (TI) is a measurement that considers the physical and chemical characteristics of fruits, as proposed by Marchi (1993). The highest TI results were registered for 'Westin' and 'Jaffa' respectively; additionally, 'Oliverlands' had the lowest average (2.07 kg SS/box). 'Hamlin' results are up to 2.33 kg SS/box (Nonino, 1995) and compatible to 1.24 kg SS/box (Di Giorgi et al., 1990) and 2.25 kg SS/box (Domingues et al., 2003). Whether compared individually, all orange cultivars presented TI above Donadio et al. (1999) results, except for Rubi and Westin cultivars.

Table 2. Average values of fruit chemical characteristics (SS, TA, SS/TA, juice and TI) of eighteen sweet orange cultivars. EECB, Bebedouro-SP, 2005.

	SS	TA	SS/TA	Juice	TI
	—— ºBrix ——	——— % ———		— % —	— kg SS/box —

Oliverlands	11.77 def	0.88 abcd	13.37 cde	43.11 ab	2.07 b
Torregrosa	11.80 def	0.95 abcd	12.44 e	54.93 ab	2.64 ab
Finike	12.53 abcde	1.02 a	12.29 e	48.72 ab	2.49 ab
Hamlin	13.60 a	0.72 ef	18.98 b	40.35 b	2.24 ab
Kawata	12.97 abcd	0.89 abcd	14.63 cde	49.09 ab	2.59 ab
Cadenera	12.10 cdef	0.94 abcd	12.84 de	46.66 ab	2.30 ab
Mayorca	13.47 ab	0.84 cdef	15.97 c	45.51 ab	2.50 ab
João Nunes	12.43 abcde	0.53 g	23.46 a	49.06 ab	2.49 ab
Westin	13.27 abc	0.69 fg	19.32 b	53.80 ab	2.91 a
Jaffa	12.50 abcde	0.86 bcde	14.59 cde	56.20 a	2.85 a
Moro	11.17 f	0.81 def	13.76 cde	54.32 ab	2.47 ab
Sanguinea	11.53 ef	0.86 bcde	13.42 cde	50.79 ab	2.39 ab
Biondo	12.43 abcde	1.01 ab	12.41 e	49.79 ab	2.53 ab
Pineapple	12.47 abcde	0.79 def	15.7 cd	47.53 ab	2.42 ab
Homosassa	11.83 def	0.81 def	14.63 cde	50.31 ab	2.43 ab
Early Oblong	12.33 bcdef	0.99 abc	12.45 e	50.49 ab	2.54 ab
Tarocco A	12.07 cdef	0.88 abcd	13.83 cde	47.22 ab	2.33 ab
Rubi	12.73 abcde	0.84 cdef	15.13 cde	48.57 ab	2.52 ab
S.D.	3.25	6.15	6.54	9.97	10.08

Averages followed by the same letter in columns do not differ among them by Tukey test at 0.01 probability error. SS = soluble solids; TA = titratable acidity; TI = technological index; S.D. = standard deviation.

4 - CONCLUSION

In conclusion, the results showed high variability among orange cultivars studied in relation to fruit quality parameters. In this way, some cultivars presented potential for consumption as fresh fruit and others for industry, indicating the importance of the diversification.

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REFERENCES

ANDRIOLLI, I.; CENTURION, J. F.; MARQUES JUNIOR, J. *Levantamento detalhado dos solos da Estação Experimental de Citricultura de Bebedouro*. Jaboticabal: FCAV-UNESP, 1994. 19p. (Relatório).

ARAÚJO, H. P. P. *Determinação e comparação de algumas características dos frutos de laranjeiras doces Valência e Natal (Citrus sinensis L. Osbeck) em Jaboticabal*. Jaboticabal-SP, 1976, 41f. (Monografia) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista.

BLUMER, S.; POMPEU JÚNIOR, J.; GARCIA, V. X. P. Características de qualidade oferecidads por variedades de laranjas (*Citrus sinensis* L. Osbeck) com baixa acidez. In: Congresso Brasileiro de Fruticultura, 16., 2002, Belém. *Anais*... 2002. CD ROM.

BORDIGNON, R.; MEDINA FILHO, H. P.; SIQUIRA, W. J.; PIO, R. M. Características da laranjeira 'valencia'sobre clones e híbridos de porta enxertos tolerantes à tristeza. *Bragantia*, v.22, n.3, 2003, p.381-395.

DI GIORGI, F.; IDE, B.Y.; DIB, K.; MARCHI, R.J.; TRIBONI, H.R.; WAGNER, R.L. Contribuição ao estudo do comportamento de algumas variedades de citros e suas implicações agroindustriais. *Laranja*, v.11, n.2, 1990, p.567-612.

DOMINGUES, E. T.; TULMANN NETO, A.; TEÓFILO SOBRINHO, J.; MATTOS JÚNIOR, D.; POMPEU JÚNIOR, J.; FIGUEIREDO, J. O. Seleção de variedades de laranja quanto à qualidade do fruto e período de maturação. *Laranja*, v.24, n.2, 2003, p.471-490.

DONADIO, L. C.; FIGUEIREDO, J. O.; PIO, R. M. *Variedades cítricas brasileiras*. Jaboticabal: FUNEP, 1995. 228p.

DONADIO, L. C.; STUCHI, E. S.; POZZAN, M.; SEMPIONATO, O. C. *Novas variedades e clones de laranja doce para indústria*.

Bebedouro: UNESP/FUNEP/EECB, 1999. 42p. (Boletim citrícola n. 8).

FAO. FAOSTAT - Statistics Database. Disponível em: <http://apps.fao.org/>. Acesso em 10 fev. 2006.

FERREIRA P.V. *Estatística experimental aplicada à Agronomia*. Maceió: UFAL, 2000. 68p.

FIGUEIREDO, J. O. Variedades copas de valor comercial. In: RODRIGUES, O.; VIEGAS, F. C. P. (Coord.). *Citricultura brasileira*. Campinas: Fundação Cargill, 1991. v1, p. 228-264.

HODGSON, R. W. Horticultural varieties of citrus. In: REUTHER, W. (Ed.) *The citrus industry*. Berkeley: University of California Press, 1967. p.431-591.

HOLLAND, N.; MENEZES, H. C.; LAFUENTE, M. T. Carbohydrates as related to the heat-induced chilling tolerance and respiratory rate of 'Fortune' mandarin fruit Harvested at different maturity stages. *Postharvest Biology and Technology,* v.25, 2002, p.181–191.

INSTITUTO ADOLFO LUTZ. 1976. Métodos físicos e químicos para análise de alimentos. Instituto Adolfo Lutz, São Paulo, SP.

MARCHI, R. J. *Modelagens de curvas de maturação na laranja 'pera' (Citrus siensis Osbeck) na região de Bebedouro-SP*. Jaboticabal-SP, 1993, 83f. (Dissertação) - Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista.

NEGRI, J. D. *A cultura dos citros*. Campinas: CATI, 1996. 35p. (Boletim Técnico, 228).

NONINO, E. Variedades de laranja para fabricação de sucos. *Laranja,* v.16, n.1, 1995, p.119-132.

REUTHER, W. *Climate and citrus behavior*. In: REUTHER, W. (Ed.). *The Citrus Industry*. Berkeley: University of California Press, 1973. p. 280-337.

STEGER, E. Trinta anos de desenvolvimento em processamento de citros, histórico, estado da arte e visão geral. *Laranja*, v.11, n.2, 1990, p.463-502.

STOREY, R.; TREEBY, M.T. Seasonal changes in nutrient concentrations of navel orange fruit. *Scientia Horticulturae*, v.84, 2002, p.67-82.

VIÉGAS, F. C. P. A industrialização dos produtos cítricos. In: RODRIGUEZ, O.; VIÉGAS, F.; POMPEU JÚNIOR, J.; AMARO, A. A. (Eds.). *Citricultura brasileira*. 2 ed. Campinas: Fundação Cargill, 1991. v.2, p.898-921.

VOLPE, C. A.; SCHÖFFEL, E. R.; BARBOSA, J. C. Influência da soma térmica e da chuva durante o desenvolvimento de laranjas-'valência' e 'natal' na relação entre sólidos solúveis e acidez e no índice tecnológico do suco. *Revista Brasileira de Fruticultura*, v.24, n.2, 2002, p.436-441.

WASHOWICZ, C. M.; CARVALHO, R. I. N. *Fisiologia vegetal e pós-colheita*. Curitiba: Champangnat, 1992. 424 p.

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