PHYSICO-CHEMICAL CHARACTERIZATION OF 'ZARCO HS' YELLOW BELL PEPPER FOR DIFFERENT RIPENESS STAGES

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ABSTRACT: The bell pepper presents alterations in its composition and its properties with the process of senescence during ripening. These composition and textual factors are part of the quality of the fruit and therefore of the selection. This permits the correct knowledge of the factors necessary for post-harvest measures, so that they can be adequately applied. The aim of this study is to analyze the 'Zarco HS' yellow pepper at various levels of ripeness taking into account its physico-chemical properties (titratable acidity, pH, total soluble solids, water content, and ascorbic acid), in order to understand this behavior during the ripening process. Bell peppers were separated based on their yellow percentage, which varied from 0% to 100%, and for each percentage five fruits were chosen as replicates. They were compared to 0%, 25%, 50%, 75% and 100% levels of ripening, due to the difficulty of the methodology in identifying the smaller differences between coloring. The 'Zarco HS' yellow bell pepper presents greater levels of soluble solids and lower levels of malic acid as the percentage of external yellow coloring increases. The yellow bell peppers, especially when totally yellow, represent an important source of vitamin C.
Key words: *Capsicum annuum*, quality, ripening

CARACTERIZAÇÃO FÍSICO-QUÍMICA DE PIMENTÃO AMARELO 'ZARCO HS' EM DIFERENTES ESTÁDIOS DE MATURAÇÃO

RESUMO: O pimentão apresenta, durante seu amadurecimento, alterações com o processo de senescência. Estes fatores de composição e propriedades texturais fazem parte da qualidade de frutas e hortaliças e, portanto da seleção. Isto faz com que seja necessário o correto conhecimento destes fatores, para que, através de testes físico-químicos, as tecnologias de conservação após a colheita possam ser adequadamente aplicadas. Este trabalho teve por objetivo analisar o pimentão amarelo 'Zarco HS' com vários graus de maturação quanto às propriedades físico-químicas (acidez titulável, pH, sólidos solúveis totais, teor de umidade e ácido ascórbico), para conhecimento deste comportamento durante o processo de amadurecimento. Os pimentões foram separados pela porcentagem de amarelo, que variou de 0% a 100%, e para cada porcentagem foram escolhidos 5 frutos, sendo cada fruto uma repetição. Os frutos foram comparados por faixas de amadurecimento, 0%, 25%, 50%, 75% e 100% devido à dificuldade de metodologia para identificar diferenças menores entre as colorações. O pimentão amarelo 'Zarco HS' apresenta níveis maiores de sólidos solúveis e níveis menores de ácido málico conforme aumenta a porcentagem externa de coloração amarelo. Pimentões, principalmente os totalmente amarelos, representam importante fonte de vitamina C.
Palavras-chave: *Capsicum annuum*, qualidade, amadurecimento

INTRODUCTION

Bell peppers present alterations in their composition and properties due to senescence during ripening.

Based on the Brazilian Program for the Improvement of Commercial Standards and Horticultural Packaging, (CEAGESP, 1998) the color of the bell pepper is classified by means of each sub-group: "red, yellow and orange fruit sub-groups should present more than 80% of their characteristic color on the surface".

During ripening, the composition and textural properties change with the senescence process. These composition factors and textural properties are part of

the quality of the fruits and vegetables and therefore of their selection. Post-harvest conservation techniques can be adequately applied whit the correct knowledge of these factors, using a physico-chemical test.

During ripening the polysaccharides of the cell wall are broken up with a consequent increase in sugar levels. There is also a decrease in the levels of soluble solids due to the complete metabolization of the majority of the soluble carbohydrates during respiration. The equilibrium of these activities in the 'Valdor' bell pepper produces an increase in the level of total soluble solids, followed by a fall after 12 days of storage, and in the tomato a progressive increase in the level of soluble solids (Hanna, 1966; Mattoo et al., 1975; Kader et al., 1977; Vicentini et al., 1999).

Cochran (1964) verified a drop in the pH of the bell pepper during its transformation from unripe green to the red stage, while Vicentini et al. (1999) showed that this difference was not significant. Tomatoes, in the *breaker* and *mature green* stages, present a lower pH than when ripe (Kader et al., 1977), and at room temperature this characteristic tends to be more differentiated. Red bell peppers present 30% higher vitamin C levels than the green bell peppers (Howard et al., 1994).

The aim of this study was to analyze the 'Zarco HS' yellow bell pepper at various degrees of ripening in terms of physico-chemical properties, to understand this behavior during the ripening process.

MATERIAL AND METHODS

The experiments were carried out in Campinas-SP, Brazil (22°48' S, 47°03' W, 640 m). Fruits from the 'Zarco HS' yellow bell pepper, a variety chosen due its large consumption in the Campinas region, were picked on the same day in greenhouses from a farm located in Salto-SP, Brazil (23°13' S; 47°17' W, 512 m). Five fruits of each percentage of yellow 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% color were used, each fruit being a replication. Fruits were analyzed on the same days in relation to levels of:

Titratable acidity: determined by means of 10 g of pulp ground in a blender and homogenized with 90 mL distilled water. NaOH (0.11 mol L^{-1}) was used as a standardized titratation solution. Results were expressed in grams of malic acid per 100 g of sample;

pH: using a digital pHmeter with the application of the electrode directly in to the blended pulp;

Soluble solids: bench refractometer type of ± 0.0003 precision placing a small sample of blended pulp on the reading prism. Results were expressed as °Brix;

Water content: 5g were taken from each replication, cut into pieces, dried in a forced air circulation oven at 70°C, until constant weight. Results were expressed in percentage;

Ascorbic acid: determined by the titratability of 3 g of the blended pulp homogenized with 50 mL of oxalic acid at a concentration of 12%. The titratable solution consisted of 2.6 sodium indophenol dichlorophenol. Results were expressed in mg of ascorbic acid per 100 g of pulp.

Due to the similarity between the coloring percentages, which were separated visually, it was decided to consider the levels of ripening, obtaining five treatments (0%, 25%, 50%, 75% and 100%). These levels of ripening were formed by the aggregation of the relative values. Fruits presenting 0% yellow coloring formed the 0% level; fruits presenting 10%, 20% and 30% levels formed the 25% level; fruits with 40%, 50% and 60% formed the 50% level; fruits with 70%, 80% and 90% formed the 75% level, and fruits presenting 100% formed the 100% level. Therefore, the raw data of the replications, previously analyzed for each corresponding yellow coloring percentage, was carried out for these levels of ripening, resulting in five replications per treatment.

The experimental design was completely randomized with five treatments and five replications. The results were submitted to variance analysis and the averages were compared by the Tukey test (P£0.05) using the statistical ESTAT package (1992).

RESULTS AND DISCUSION

The yellow bell peppers, with any percentage of coloring, except those totally green, already present their maximum ripening, which transform them into attractive fruit and ready for human consumption, according to Chitarra & Chitarra (1990). Based on these same authors, it was possible to verify the changes which took place and which make this product tastier at different levels of ripening at which the fruits were picked, corresponding basically to the changes in the sensorial factors of taste, odor and texture.

Titratable acidity (TA) of the yellow bell peppers increased with ripening (Table 1). While the fruit ripens the metabolic reactions increase, increasing the concentration of organic acids involved in the Krebs cycle. Apart from this, these acids make up the energetic reserves and the metabolic reactions that involve the synthesis of pigments, enzymes and other materi-

Table 1 - Titratable acid levels (TA), pH, total soluble solids (TSS), ascorbic acid (AA) and water content for 'Zarco HS' yellow bell peppers picked at different percentages of yellow color of the fruit.

Treatment (% yellow color)	TA	pH	TSS	AA	Water Content
	g 100 g^{-1}		°Brix	mg 100 g^{-1}	%
0	0.110[a]*	4.8	5.76[a]	167	92[a]
25	0.188[b]	4.8	6.73[b]	165	91[ab]
50	0.184[b]	4.8	6.90[b]	168	91[ab]
75	0.203[bc]	4.7	7.45[c]	177	91[ab]
100	0.217[c]	4.8	7.93[c]	188	90[b]
Average	0.180	4.77	6.95	173	91
Standart Deviation	0.01	0.05	0.28	24.47	0.68
Coefficient of Variation (%)	8.20	1.08	4.02	14.13	0.75

*Averages followed by at least one common letter, in the columns, for each variable, do not differ among each other, by the Tukey test ($P \leq 0.05$).

als and the degradation of pectins and celluloses, which are essential for the ripening process. The organic acids are active substances during ripening in these alterations (Chitarra & Chitarra, 1990). For the totally green bell peppers, these organic acids are present in small quantities, as the ripening process has not yet started, presenting differences in relation to the other stages of ripening. This same behavior was observed by Molinari et al. (1999) when they studied varieties of bell peppers from Florida, USA.

The production of the organic acids did not interfere on the pH of the 'Zarco HS' yellow bell peppers, even when these two parameters are directly related. The total soluble solids (TSS) increased as ripening of the fruit increased due to the greater degradation or biosynthesis of the polysaccharides and the accumulation of sugars. The metabolic processes related to the advance of ripening, probably due to disassociation of some molecules and structural enzymes in soluble compounds, directly influence the levels of total soluble solids, where fruits in advanced stages of ripening present the highest levels of soluble solids (Lyon et al., 1992). Based on J.K. Brecht apud Molinari et al. (1999) the content of total sugars in bell peppers with $^1/_3$ and complete ripening is approximately 30% and 50% greater, respectively.

Considering the levels of ripening, the yellowing of the bell pepper increases the greater the levels of titratable acidity and soluble solids, hindering the relationship of these two parameters with a taste indicator, TSS/TA, which is an important qualitative parameter. The process of ripening of the fruit causes changes in the permeability of the cell membranes (Goodwin & Mercer, 1972; Suslow, 2000), making them more sensitive to the loss of water, therefore the bell peppers, which are completely ripe demonstrate a statistically lower level than those totally green.

Ascorbic acid, known as vitamin C, needs to be consumed via food or medicine, as it is not produced in the human organism. For Linus Pauling, the Nobel Prize winner twice, vitamin C is a micronutrient that participates in nearly all chemical reactions that occur in the human organism, being fundamental in many of them (Manela-Azulay et al., 2003). Ascorbic acid is the least complex vitamin found in plants and is synthesized from glucose or some other simple carbohydrate (Kays, 1991).

Thus, during the ripening of the yellow bell pepper, the levels of ascorbic acid (AA) tend to increase (Table 1), as the percentage of yellow increased the titratable acidity and the total soluble solids also increased. The bell pepper, green or totally yellow represents an important source of vitamin C for human consumption, presenting values of 173 mg 100 g^{-1}, higher than those of mango (84 mg 100 g^{-1}), guava (67 mg 100 g^{-1}) and orange (40 mg 100 g^{-1}) (Toda Fruta, 2004). Since the bell pepper is a vegetable when commercialized green, at a small commercial value, the introduction of this fruit to the consumer's table reduces the necessity of medical prescription in terms of the supply of this nutrient for the lower social income class.

The values of ascorbic acid found in the 'Zarco HS' yellow bell pepper is in agreement with those indicated by USDA apud Molinari et al. (1999), or in other words, that the level of ascorbic acid in completely green and yellow bell peppers is 128 mg and 190 mg for each 100 g, respectively.

CONCLUSION

'Zarco HS' yellow bell pepper presents greater levels of soluble solids and lower levels of malic acid as the percentage of external yellow coloring increases. The external yellow strip of coloring with 50% yellow color represents an important area for the commercial harvest of this product, since based on PBMPCEH (1998) the yellow pepper should be commercialized with an 80% minimum characteristic color. However, due to the actual lack of post-harvest conservation technology, the 50% level of coloring allows the product to reach the demanded levels between the harvest and commercialization. 'Zarco HS' yellow bell peppers, especially the totally yellow ones, represent an important source of vitamin C.

ACKNOWLEDGEMENTS

To FAPESP (99/04969-7), CNPq and Capes for the financial support.

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Received August 16, 2005
Accepted January 10, 2007