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Lycopene Concentration and Physico-Chemical Properties of Tropical Fruits*

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ABSTRACT

In this study, the lycopene concentration and physico-chemical properties of tropical fruits in ripe for immediate consumption was evaluated. Chonto tomatoes had greater lycopene contents than Milano or Long Life Milano tomatoes, 107 as against 89 and 58 µg/(g fresh weight), respectively ($p < 0.001$). Jenny watermelon had a higher lycopene concentration than guava or Maradol papaya, 110 as against 36 and 6 µg/(g fresh weight), respectively ($p < 0.001$). Milano tomato and Maradol papaya presented the best physicochemical properties than other fruits. The major concentration of lycopene in Chonto tomatoes and Jenny watermelon offers an important alternative to reduce the risk of cancer in the Colombian population.

Keywords: Tomato; Guava; Watermelon; Papaya; Solid Soluble; Titratable Acidity

1. Introduction

New life styles have driven consumers away from healthy dietary habits. As a matter of fact, their increasing concern about their health has prompted the need for food products which contribute to the prevention of illness. Fruits and vegetables are a good source of natural antioxidants, containing many different antioxidant components which provide protection against harmful-free radicals and have associated with lower incidence and mortality rates of cancer and heart diseases in addition to a number of other health benefits [1]. Among these compounds, the carotenoids constitute an important group in human diets and display, in addition to their vitamin activity, several other biological activities including antioxidant capacity, blue light filtering, modulation of immune function, and regulation of cell differentiation and proliferation [2]. Some 70% - 90% of the carotenoid content of the human diet is supplied by fruit and vegetables [3]. The most efficient carotenoid antioxidant is lycopene which was first isolated in 1910 [4,5]. It is mainly produced by higher plants, in which it protects cells against photo-oxidation [6]. Lycopene is an important intermediate in biosynthesis of vitamin A precursor carotenoids like β-carotene and β-cryptoxanthin. As described in detail by Fraser and Bramley (2004) [7], prolycopene (7Z, 9Z, 7'Z, 9'Z-lycopene) is formed by successive dehydrogenations of phytoene and ζ-carotene catalyzed by phytoene desaturase (PDS) and ζ-carotene desaturase (ZDS), respectively. Subsequently, prolycopene is transformed to all-E-lycopene by a carotene cis-transisomerase [7,8]. The chief source of lycopene in the human diet is the tomato, which contains 29.37 - 150 µg/g fresh weight (fw) [9,10]. Along with the carotenoids, sugars and organic acids determine the quality of the fruits and vegetables, these parameters may supply important information to the consumer in terms of recognizing a more nutritional product. Several works have established the role of soluble solid content, acids and sugars in the taste and flavor intensity of fruits and vegetables [11]. However, Colombia is limited to information that consumers have about the quality of different fruits and vegetables grown in this tropical country. Since this is one of the main reasons for low fruit and vegetable consumption reaching only 190 grams per person per day, which values lower than that established by the World Health Organization (WHO) who recommends a minimum con-

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sumption of 400 grams per person per day of fruits and vegetables. The present study was conducted to determine the concentration of lycopene and physic-chemical properties tropical fruits.

2. Materials and Methods

2.1. Plant Material

We studied three cultivars of tomato (*Solanum lycopersicum* L.) Milano, Long Life Milano (LL-Milano), and Chonto and one cultivar of each of three different fruits: watermelon (C*itrullus lanatus* L. "Jenny"), guava (*Psidium guajaba* L. "Pera") and papaya (*Carica papaya* L. "Maradol") were purchased in the local market, ripe for immediate consumption, and were transported to the laboratory, and stored at 4˚C until analysis. Six samples in each case were evaluated, and at least two determinations were performed for each analysis, and the average value was reported.

2.2. Physicochemical Analyses

Weight per individual fruit was determined as the mean of the individual weights of all the fruits in all three samples. The pH, titratable acidity (TA) and total soluble solidscontent (SS) of two homogenized subsamples of each sample were determined by the official Colombian methods [12-14]; TA was expressed as (g citric acid)/(100 g·fw) [for watermelon, (g malic acid)/(100 g·fw)], and SS as ˚Brix. A ripeness index RI was defined as SS/TA. Lycopene was extracted in duplicate and quantified as per Barrett *et al*. (2001) [15]. Briefly, 0.1 g of the sample was weighed in a tube, and then 7 mL of 4:3 ethanol/hexane was added, the tube was capped, covered with aluminum foil, and the flask was then placed in crushed ice and shaken for 1 h, after which 1 mL of distilled water was added and shaking was continued for a further 5 min. A sample of the organic (hexane) phase was read at 503 nm compared with hexane in a Genesys 10 UV-Vis spectrophotometer (Thermo Electron Scientific Instruments LLC, Madison, WI, USA).

The lycopene content in the hexane extracts were then calculated according to: μg lycopene/g·fw = (A_{503} × 537 × 2.7)/(0.1 × 172) where 537 g/mole is the molecular weight of lycopene, 2.7 is the volume (mL) of the hexane layer, 0.1 g is the weight of sample added, and 172 mM^{-1} is the extinction coefficient for lycopene in hexane.

2.3. Statistical Analysis

Data are presented as the means ± standard deviations of the six samples in each case. The experimental date conform to one-factor complete randomized blocks designs, and were analyzed by none-way ANOVAs using fixed effects models and post hoc Tukey tests. Student's t-tests were used to compare titratable acidity (TA) and ripeness index RI in tropical fruits. All analyses were performed using SPSS for Windows v.17.

3. Results and Discussion

3.1. Lycopene Concentration

In **Tables 1** and **2**, relates lycopene content in the fruits analyzed, and significantly different (p < 0.001) in all samples. Chonto having a significantly greater content than Milano [107 as against 88 μg/g·fw], and Milano a significantly greater content than LL-Milano [58 μg/g·fw] (**Table 1**). Lycopene is the major carotenoid of tomato and comprises about 83% of the total pigment present [16]. Our values of lycopene (**Table 1**), are higher than

Table 1. Characteristics of Chonto, Milano and Milano Larga Vida (LV) tomatoes: means ± deviations standard of two independent analyses of each of six samples (n = 12).[1]

Cultivar	Weight (g)	pH	Soluble solids (˚Brix)	Titratable acidity[2]	Ripeness index RI	Lycopene [μg/(g·fw)]
LL-Milano	192.50 ± 2.97^a	4.67 ± 0.02^a	3.31 ± 0.10^b	0.37 ± 0.07^b	9.08 ± 1.68^a	57.78 ± 1.48^c
Chonto	117.86 ± 9.26^b	4.35 ± 0.12^a	4.27 ± 0.50^a	0.54 ± 0.03^a	7.95 ± 1.15^a	107.07 ± 1.69^a
Milano	196.80 ± 9.07^a	4.11 ± 0.57^a	4.53 ± 0.23^a	0.41 ± 0.02^b	10.94 ± 0.77^a	88.45 ± 9.97^b
P value	$p < 0.001$	NS	$p < 0.01$	$p < 0.05$	NS	$p < 0.001$

[1]Except for weight values, which are the means ± standard deviations of the individual weights of all the fruit in all six samples; [2]In (g citric acid)/(100 g·fw). Values with the same associated letter are not significantly different (Tukey, p ≤ 0.05).

Table 2. Characteristics of fruit: means ± deviations standard of two independent analyses of each of six samples (n = 12).[1]

Fruit	Weight (g)	pH	Soluble solids (˚Brix)	Titratable acidity[2]	Ripeness index RI	Lycopene [μg/(g·fw)]
Watermelon	2452 ± 651.77^a	5.33 ± 0.21^a	7.36 ± 1.55^a	0.08 ± 0.02$^-$	95.35 ± 39.03$^-$	110.05 ± 8.78^a
Guava	154.20 ± 0.01^c	3.91 ± 0.11^b	7.53 ± 0.52^a	0.42 ± 0.04^a	18.06 ± 2.87^b	36.10 ± 4.50^b
Papaya	977.30 ± 0.05^b	5.24 ± 0.77^a	8.57 ± 1.50^a	0.04 ± 0.01^b	184.05 ± 53.22^a	6.21 ± 1.50^c
P value	$p < 0.001$	$p < 0.01$	NS	$p < 0.001$	$p < 0.001$	$p < 0.001$

[1]Except for weight values, which are the means ± standard deviations of the individual weights of all the fruit in all six samples; [2]In (g malic acid)/(100 g·fw) for watermelon, and (g citric acid)/(100 g·fw) for guava and papaya; ⁻Not available. Values with the same associated letter are not significantly different (Tukey, p ≤ 0.05).

those reported by Hernández *et al*. (2006) [17]. [19 - 26 μg/(g·fw)], and Rodríguez-Amaya *et al*. (2008) [18]. [31 - 35 μg/(g·fw)]; but similar to those [77 - 150 μg/(g·fw)] [10], and [55 - 150 μg/(g·fw)] [19].

Lycopene to constitute 84% - 97% of the total carotenoid content of watermelon Perkins-Veazie *et al*. (2006) [20] and Perkins-Veazie and Collins (2006) [21]. Our values (**Table 2**), are higher than those reported by other authors [50 - 73 μg/(g·fw)] [22], [50 - 65 μg/(g·fw)] [23], [39 - 49 μg/(g·fw)] [24], and [33 - 41 μg/(g·fw)] [18], and is within the range 30 - 120 μg/(g·fw) reported by Perkins-Veazie *et al*. (2006) [20] and Charoensiri *et al*. (2009) [25]. According to [22,20,26] differences in watermelon lycopene content are mainly due to differences in genetic make-up, illumination and water supply. Researchers [27,28] found watermelons to have lycopene concentrations respectively 60% and 40% higher than those of tomatoes; in the present study the lycopene content of watermelon, 110 g/fw, was 2.8% greater than that of Chonto tomato, 24% greater than that of Milano, and 90% greater than that of LL-Milano (**Tables 1** and **2**).

In guava, around 80% of carotenoid content is lycopene [29]. Lycopene content Is lower (**Table 2**), than those reported by Rodríguez-Amaya (1999) [47 - 53 μg/(g·fw)] [30]. Rodríguez-Amaya, *et al*. (2008) [53 - 83 μg/(g·fw)] [18], and Oliveira *et al*. (2010) [55 - 76, 50 μg/(g·fw)] [31], but higher than the very low values observed by Inocent *et al*. (2007) [0.84 - 0.90 μg/(g·fw)] [32]; these differences are probably due to both pre-harvest and post-harvest factors. Lycopene contributes 65% of the total carotenoid content of pink papaya (the other major carotenoids being cryptoxanthin and-carotene). Our values (**Table 2**), is less than those reported by other authors [16 - 80 μg/(g·fw)] [18], [19 - 40 μg/(g·fw)] [30], [31 - 42.81 μg/(g·fw)] [31], [16 - 174 μg/(g·fw)] [33], [13 - 33 μg/(g·fw)] [34], and [14 - 34 μg/(g·fw)] [35], once more, both pre-harvest and post-harvest factors seem likely to be involved in these differences. On the basis of the results of this study, published recommendations for daily intake of lycopene (35 mg/day) [36], and of fruit and vegetables in general (400 g/day) [37], would be complied with by the following daily rations (among innumerable other combinations): 606 g of Milano LV tomato; 400 g of Chonto tomato, Milano tomato, Jenny watermelon; 276 g of Jenny watermelon plus 124 g of guava; or 331 g of Jenny watermelon plus 69 g of Maradol papaya.

3.2. Physico-Chemical Properties

The weight, pH, SS, TA, and RI values can be seen in **Tables 1** and **2**. The pH and RI of tomatoes fruits did not differ significantly, by contrast, weight, SS, and TA, content significant differences (**Table 1**). The three tomato cultivars differed significantly in soluble solids content ($p < 0.01$), LL-Milano having lower average SS than the others, 3.31 as against 4.3 - 4.5 Brix (**Table 1**). They did differ in titratable acidity ($p < 0.05$), Chonto having significantly more titratable acidity than Milano or LL-Milano, 0.54 as against 0.41 and 0.37 (g citric acid)/(100 g·fw), respectively (**Table 1**). The cultivar weight range (**Table 1**), is greater than those observed by authors who studied smaller tomato cultivars, e.g. 33 - 53 g [10], or 5 - 75 g. [38]. The pH (**Table 1**), is similar to those observed by Fernández-Ruíz *et al*. (2004) [39]. 3.86 - 4.79 g. The TA range of average values (**Table 1**), is similar to those reported by Ruíz *et al*. (2005) [40], and Odriozola-Serrano *et al*. (2008) [41], 0.27 - 0.54 and 0.34 - 0.59 (g citric acid)/(100 g·fw), respectively. The SS values (**Table 1**), were lower than those reported by Moraru *et al*. (2004) [10], Ruíz *et al*. (2005) [40], Fernández-Ruíz *et al*. (2004) [39] 4.77 - 5.73, 4.10 - 5.70 and 3.97 - 7.27 Brix, respectively. The RI (**Table 1**), this range lies within that observed by Rodríguez-Burruezo *et al* (2005) [42], 5.5 - 15.5, and is narrower and mostly lower than that observed by Ruíz *et al*. (2005) [40], 10.1 - 21.5.

The SS of fruits did not differ significantly, by contrast, weight, pH, TA, and RI, significant differences (**Table 2**). The average SS value (**Table 2**), is somewhat lower than the range of 8.26 - 12.50 Brix observed in watermelons by Proietti *et al*. (2008) [43], Perkins-Veazie and Collins (2004) [23], and Bang *et al*. (2004) [22]. Similarly, the pH (**Table 2**), is somewhat more acid than the range pH 5.57 - 5.84 that was found by these authors. However, the titratable acidity (**Table 2**), coincides exactly with that reported by Proietti *et al*. (2008) [43], for ungrafted Ingrid watermelon, and the RI value (**Table 2**), is accordingly slightly smaller than that obtained by these authors, 98.86. The pH, TA and SS values (**Table 2**), are all within or close to the ranges observed among guavas by Dos Reis *et al*. (2007) [44], and Brunini *et al*. (2003) [45], pH 3.84 - 3.86, TA 0.41 - 0.67 (g citric acid)/(100 g·fw), SS 1.27 - 9.09 Brix. The pH, TA and RI values, are all within, and the SS value just slightly below (**Table 2**), the ranges observed by Santana *et al*. (2004) [46], among 12 Brazilian papaya cultivars: pH 4.19 - 5.89, TA 0.04 - 0.16 (g citricacid)/(100 g·fw), SS 9-14 Brix, RI 68 - 233. Jain *et al*. (2011) [47], different values reported: pH 4.39, TA 0.316 (g citricacid)/(100 g·fw), SS 12.40 Brix, and RI 39.24.

4. Conclusion

In this work, of all the fruits analyzed in this study, that with the highest lycopene concentration was Jenny watermelon, followed by Chonto, Milano and LL-Milano tomatoes (in that order); the lycopene concentration of guava was only about one-third that of Jenny watermelon, and that of Maradol papaya about one-eighteenth. Moreover Milano tomato and Maradol papaya presented the best physicochemical properties than other fruits.

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