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Effect of ultrasound treatment on visual color, vitamin C, total phenols, and carotenoids content in Cape gooseberry juice

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ABSTRACT

Strong interest of consumers in acquiring minimally processed foods that conserve the different micronutrients has raised the need to study the effect of food processing methods on quality attributes. The aim of the study was to determine the effect ultrasound treatment on color, and the bioactive compounds (ascorbic acid, total phenols, carotenoids, and provitamin A) of Cape gooseberry juice. Color values, ascorbic acid, total phenols, carotenoids, and Retinol Activity Equivalent (RAE) were measured. The results indicate significant reductions ($p < 0.001$) in the chromaticity, yellowing index (IY), and acid ascorbic content was observed in all the juice samples sonicated. But there were significant increases ($p < 0.001$) in hue, the total color differences (TCD), total phenols, carotenoids, and RAE value as compared to control. The results demonstrated that ultrasound processing increase the availability of carotenoids, total phenols and RAE in Cape gooseberry juice.

1. Introduction

Cape gooseberry (*Physalis peruviana* L.) is an exotic fruit, native from the Andean Region (Bravo & Osorio 2016; Olivares-Tenorio, Dekker, Verkerk, & van Boekel, 2016). The main producer of Cape gooseberry in the world is Colombia, and is the exotic fruit most exported by this country (Zapata, Ciro, & Marulanda, 2016). This fruit is an important source of bioactive compounds such as ascorbic acid, vitamin A, vitamin B complexes, minerals, tocopherols and carotenoids (Bravo & Osorio 2016). These bioactive compounds provide health benefits, because they are hepatoprotective, anti-inflammatory antioxidant, anticarcinogenic, anti-diabetic, and prevention of cardiovascular diseases (CVD) and coronary heart disease (Ramadan 2011, and Zapata et al., 2016).

In fruit derivatives, juice occupies an important segment of the market; in 2011 38,948 million liters of juice were consumed worldwide (Silva, Sabino, Oliveira, Torres, & Sousa, 2016), and the juice industry is currently interested in offering exotic fruit juices to meet the growing consumer demand for products rich in micronutrients and exotic flavors. Thermal processing is the method of conservation for shelf-life extension of fruit juices; this heat treatment inhibits microorganisms to levels of 5-log reduction in number of the most thermo-resistant pathogens (Cervantes-Elizarrarás et al., 2017). However, thermal processing in fruit juices can affect visual color, ascorbic acid, carotenoids, phenolic and vitamin A.

The current trend of fruit juices is aimed at satisfying consumers who demand minimally processed products that preserve the original nutritional value of the fresh fruit. In response, research has focused on non-thermal processes, which guarantees commercial stability without affecting the quality of food (Cervantes-Elizarrarás et al., 2017). One of the alternatives to heat treatments in fruit juice is the ultrasound processing, emerging technology of low cost by its low energy consumption and reduced processing time (Aadil et al., 2015; Bhat & Goh 2017). The effect of ultrasound on the quality of fruit juices has been previously investigated in grapefruit juice (Aadil et al., 2015), orange juice (Khandpur & Gogate 2015), and pear juice (Saeeduddin et al., 2016), blackberry juice (Cervantes-Elizarrarás et al., 2017), and strawberry juice (Bhat & Goh 2017). The main results suggest that it is a method that preserves the quality of fruit juices by retaining much of the bioactive compounds and reducing pathogenic microorganisms. However, in spite of the agro-industrial potential of this fruit, there is no scientific literature in research reports aimed at evaluating the effect of ultrasound on color, ascorbic acid, phenolic compounds and carotenoids in Cape gooseberry juice. Therefore, the objective of the present research was to determine the effect ultrasound treatment on the visual color and bioactive compounds (ascorbic acid, total phenols, carotenoids, and provitamin A) of Cape gooseberry juice.

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2. Material and methods

2.1. Chemical

Glacial acetic acid, 2.6-dichloroindophenol, ethanol, hexane, sodium carbonate and ascorbic acid were obtained from Merck. Folin-Ciocalteu and Gallic acid were purchased from Sigma–Aldrich.

2.2. Juice preparation

Cape gooseberry fruits were purchased from local market in Palmira Valle del Cauca, Colombia fruits were selected in stages of maturing consumption for processing. Fresh fruits were crushed and screened using a commercial juice extractor. Juice was filtered a single layer of muslin cloth to filter out seeds, coarse particles and impurities. Juice was diluted in distilled water (ratio 1:1) according to Rojas, Leite, Cristianini, Alvim, and Augusto (2016), and the juice was stored at 4 °C prior to processing.

2.3. Ultrasonic treatment

The juice was divided into five parts as control samples (0 min), heat pasteurization (HP), ultrasonic for 10 min (US10), ultrasonic for 20 min (US20), and ultrasonic for 40 min (US40). Juice samples (80 mL) were placed in a 100 mL glass beaker. HP was carried out by heating the juices at 80 °C temperature for 10 min using a water bath. The treatment time of 10 min was decided based on the requirement to reduce at least 5 log reductions in the microbial count of the FDA (Santhirasegaram, Razali, & Somasundram, 2013). The ultrasound treatment was determined according to Zafra-Rojas et al. (2013), where they report that juice samples subjected to the action of the ultrasound during time, equal to or >15 min, allow to comply with sanitary regulations of commission regulation of on microbiological criteria for foodstuffs, of the Commission of the European Communities (6 log reductions in the microbial count).

The samples processed by ultrasound were treated in an ultrasonic bath system (Ultrasonic Cleaner Kendal HB-S-49DHT, with 42 kHz frequency and maximum ultrasonic power of 240 W, the internal dimension: 300 mm × 240 mm × 150 mm). Ultrasound equipment with water circulation in order to control the process temperature to be stable at 30 (±2) °C. The actual power dissipated in the ultrasonic bath was 190–210 W, which was determined by calorimetric method reported by Kiani, Sun, and Zhang (2012). Samples ultrasound and thermal treatment were performed in dark to avoid any possible interference with light, and were immediately cooled by immersing in an ice-water bath after treatments and stored at 4 °C till further analysis.

2.4. Physicochemical analysis

The pH, titratable acidity (TA) and total soluble solids (TSS) of juice sample was performed according to AOAC (1990). TA was expressed as grams of citric acid per 100 ml of juice and TSS as °Brix. The color of the juice samples was determined using a Minolta CR-400 color colorimeter. The instrument was standardized each time with a black and a white (Y = 89.5; x = 0.3176; y = 0.3347) tile using illuminant D65, and a 2° observer. Numerical values of L^*, a^* and b^* were converted into chroma (C^*), hue angle (h°), total color difference (TCD), and yellowing index (IY) using the Eqs. (1)(4)

$$C = (a^{*2} + b^{*2})^{1/2} \quad (1)$$

$$h = \tan^{-1}(b^*/a^*) \quad (2)$$

$$TCD = (\Delta a^{*2} + \Delta b^{*2} + \Delta L^{*2})^{1/2} \quad (3)$$

$$YI = (142.86b^*)/(L^*) \quad (4)$$

2.5. Determination of ascorbic acid

Ascorbic acid content was determined according to Ordóñez-Santos and Vázquez-Riascos (2010). Five mL of the sample was diluted to 100 with distilled water at 4 °C and 2 mL of the extract was mixed with 25 ml of 20% glacial acetic acid and titrated against standardized 2.6-dichloroindophenol (0.05 g/100 mL) solution. Ascorbic acid was used as standard, and the result was expressed as mg/(100 mL).

2.6. Total phenolic content

The total phenolic content of juice samples was determined using the Folin-Ciocalteu method according to the method of Aadil, Zeng, Han, and Sun (2013). The reaction mixture contained: 0.5 mL of juice samples, 1 mL of 10% Folin-Ciocalteu reagent and 2 mL of a 20% sodium carbonate. The mixture was then left in the dark for 60 min at 30 °C. The absorbance of the sample was measured at 760 nm using spectrophotometer (Genesys 20 UV–Vis spectrophotometer). A calibration curve was prepared using standard solution of Gallic acid (2–170 μg/mL, $r^2 = 0.9955$) and results were expressed as μg of Gallic acid equivalent (GAE) per gram of sample.

2.7. Determination content carotenoids and Retinol Activity Equivalents (RAE)

Carotenoids were extracted according to Barrett and Anthon (2001). Briefly, 0.1 grams 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 dis-tilled water was added and shaking was continued for a further 5 min. A sample of the organic (hexane) phase was read at 450, 444, 451, and 472 nm respectively, compared with hexane in a spectrophotometer (Genesys 20 UV–Vis spectrophotometer, Thermo Electron Scientific Instruments LLC, Madison, WI, USA). Concentration (mg/L) was calculated using the extinction coefficients ($E^{\%}_{1cm}$) in hexane: 2560, 2800, 2460, 2480 and 3540 for β-carotene, α-carotene, β-cryptoxanthin, zeaxanthin and lycopene, respectively, according to Hart and Scott (1995). Retinol Activity Equivalents (RAE) were calculated using a conversion factor of 12 for β-carotene and of 24 for the other provitamins A (α-carotene, and β-cryptoxanthin) for 1 retinol (Courraud, Berger, Cristol, & Avallone, 2013), and expressed in μg RAE/L.

2.8. Statistical analysis

Results are expressed as means ± standard deviations. Comparison between treatments (control, HP, US10, US20, and US40) was carried out by a one-way analysis of variance (ANOVA) and significant differences between mean values were determined by the Tukey pairwise comparison test at a significance level of $P < 0.05$. Statistical analyses were conducted using the SPSS 18 program for Windows. All treatments had four replicates.