Food Chemistry 215 (2017) 470–476

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Sonication treatment convalesce the overall quality of hand-pressed strawberry juice

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ARTICLE INFO

Article history:
Received 11 May 2016
Received in revised form 27 July 2016
Accepted 28 July 2016
Available online 30 July 2016

Keywords:
Strawberry fruit juice
Sonication
Cavitation
Bioactive compounds
Enzyme activity
Browning degree

ABSTRACT

Hand-pressed strawberry juice samples were subjected to sonication treatments (0, 15 and 30 min at 20 °C, 25 kHz frequency). Physicochemical properties (°Brix, pH, water activity, viscosity, titratable acidity, cloud assessment and turbidity), antioxidant compounds and activity (total phenolics, ascorbic acid, anthocyanins, free radical scavenging activity), polyphenoloxidase enzyme activity, browning degree and microbial load were evaluated. Results showed non-significant changes for °Brix, pH, water activity, titratable acidity and colour parameters in sonicated samples compared to control (0 min). Sonication treatments resulted in reduced viscosity and increased cloudiness and turbidity. Overall, treatment for 30 min showed significant enhancement in bioactive compounds under study. Besides, sonication treatment imparted non-significant changes in polyphenoloxidase activity and in browning degree. However, sonication was incompetent in reducing microbial load. Results generated from this study were encouraging and this is expected to provide platform for future commercial applications on a pilot scale.

1. Introduction

High commercial value incurred for strawberries (*Fragaria x anannassa* Duch.) is attributed to their unique taste and mouth feel. Majority of the consumers opine strawberries to be a healthy food selection due to the presence of high levels of bioactive compounds (Bhat & Stamminger, 2015a, 2015b, 2015c). However, due to their high perishability, strawberries need to be processed into products such as jam, puree, juice, etc. Because of concerns over safety and quality issues raised world over, many techniques have been proposed for preserving/retaining the original organoleptic qualities of strawberry products. Nevertheless, studies have shown strawberry products quality to be drastically compromised after processing when compared to fresh harvest (Bhat & Stamminger, 2015a, 2015b, 2015c). One of the best alternative methods for thermal processing is the ultrasound/sonication treatments, an emerging technique which holds high scope in food industry, especially due to minimal heat involved during treatment. Many literatures and reviews are available in the scientific databases highlighting the promising effects imparted on the potential applications of ultrasound treatment in food processing and preservation. Further, sonication treatment incurs low operating cost, minimal energy consumption and is more friendly towards environment (Bhat, Kamaruddin, Min-Tze, & Karim, 2011; Bhat & Stamminger, 2015b; Khandpur & Gogate, 2016).

As per the knowledge of the authors, no comprehensive report is available investigating the influence of sonication treatments on the quality of freshly prepared hand pressed strawberry juice. The prime objective of the current investigation was to determine the influence of sonication time (0, 15 and 30 min) on various quality characteristics such as the physicochemical properties (total soluble solids or °Brix, pH, water activity, viscosity, titratable acidity, cloud assessment and turbidity), antioxidants level (total phenolics, ascorbic acid, anthocyanins), free radicals scavenging activity, polyphenoloxidase enzyme activity, browning degree and microbiological analysis in hand-pressed fresh strawberry juice. The generated results are expected to be a platform for future commercial exploitation, aimed towards benefiting the consumers.

2. Materials and methods

2.1. Raw Materials and sample preparation

Fresh strawberry samples were purchased from a local supermarket (Tesco Extra, Penang). In this study, one of the most popular

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http://dx.doi.org/10.1016/j.foodchem.2016.07.160
0308-8146/

strawberry varieties, namely the 'Chandler' variety (origin of Cameron highlands) was used. This variety has an intense flavour and a unique aroma, but has very short shelf-life. Prior to experiments, fruits were examined for physical, microbial or insect infestation, and damaged fruits were discarded accordingly. Selected healthy fruits (attained with commercial maturity) were washed carefully with clean water to remove any dirt or impurities. Then, by using a sterile knife, fruits were manually cut into small cubes, followed by extraction of juice (Derossi, De Pilli, & Fiore, 2010) using a sterile hand presser (aluminum alloy fruit juicer, manufacturer Junzilan Company, China). The average yield of the juice (by weight) was 27.57 ± 4.31 per 100 g of strawberries and average yield by volume/weight was 26.74 ± 2.81 ml of juice per 100 g of strawberries.

2.2. Sonication treatment

Sonication treatment was performed immediately after the juice extraction. Strawberry juice samples were poured individually into sterile glass beaker. This was divided into 3 independent batches (designated as control or 0 min, 15 and 30 min with juice filled up to a level of 8 mm), and were subjected to sonication treatments. The sonication condition was set at 25 kHz frequency with power set at 70% (at 20 °C) with homogenous sound field distribution being monitored regularly. The treatment was performed using an 'Ultrasonic Elma® Cleaning Bath' (Model TI-H-10, Germany). The temperature was monitored to be stable at 20 °C by using a thermocouple (Bhat et al., 2011). After treatment time, strawberry juice samples were kept in a sterile beaker wrapped with aluminum foil (to maintain darkness and to avoid interference by light).

2.3. Physicochemical properties of strawberry juice (total soluble solids, pH, water activity, viscosity, titratable acidity, cloud assessment and turbidity)

Total soluble solids (TSS or °Brix value) in the sonicated and control batch of strawberry juice samples were determined using a digital refractometer (Model: HSR-500 Japan; Bhat & Stamminger, 2015a; Matsumoto, Obara, & Luh, 1983). Readings were taken at room temperature with the prism being cleaned with distilled water prior to analysing each of the samples. Further, pH of the strawberry juice samples were determined by using a pH meter (HORIBA F-21, Japan) (AOAC official method, 2000). Water activity was recorded by using water activity meter (AquaLab Water Activity Meter, USA). Regarding viscosity, this was measured by using a viscometer (Vibro Viscometer SV-10 series, Tokyo, Japan). For titratable acidity, AOAC (2000) official method was adopted. The total titratable acidity in the strawberry juice samples were calculated as:

$$TA(\%) = \frac{V \times 0.1N\ NaOH \times 0.067 \times 100}{m}$$

Where V is the titer volume of the NaOH used while m is the mass of strawberry juice in grams.

Further, for cloud assessment, 10 ml of the control and sonicated strawberry juice samples were centrifuged (at 2063×*g* at 25 °C for 10 min; Kubota Centrifuge-5100, Japan) followed by collection of supernatant and measurement of absorbance at 660 nm (UV–vis spectrophotometer, Shimadzu, Tokyo, Japan with 1 cm path length cell) (Bhat & Stamminger, 2015a; Cao et al., 2012).

Turbidity in the control and sonicated strawberry juice samples was measured at wavelength of 610 nm using spectrophotometer. The respective turbidity with distilled water as reference was calculated by the following equation:

$$\text{Transmittance (T)} = 100 \times 100^{-\text{Abs}}$$

$$Turbidity = 100 - T$$

Where Abs = absorbance and T = transmittance at an wavelength 610 m.

2.4. Colour analysis

A pre-calibrated spectrophotometer (Minolta Model CM-3500, Japan), with black and white references tiles was used to measure the colour in control and sonicated strawberry juice samples, which was expressed as values of L^* for brightness/whiteness, a^* for redness/greenness and b^* for yellowness/blueness (Bhat & Stamminger, 2015a).

2.5. Antioxidant compounds and antioxidant activity (total phenolics. ascorbic acid, anthocyanins, DPPH free radical scavenging activity)

The total polyphenolics content in control and sonicated strawberry juice samples was determined by Folin-Ciocalteu (FC) assay with results represented as mg gallic acid equivalent (GAE) per 100 g fresh weight of the sample. The preparation of gallic acid standard curve followed the procedure of FC assay, but the sample was substituted by different concentration of gallic acid (1 μg, 10 μg, 20 μg, 30 μg, 40 μg, 50 μg and 100 μg)/ml (Singleton & Rossi, 1965; Wijekoon, Bhat, & Karim, 2011).

The ascorbic acid content of control and sonicated strawberry juice samples was determined by AOAC Titrimetric Method (967.21) with results calculated as milligrams of ascorbic acid per 100 ml of the sample. Further the following formula was adopted for calculation (AOAC, 1995):

$$\text{Ascorbic acid (mg/100 g or ml)} = \frac{(titer\ volume \times concentration \times 100)}{(extract\ aliquot\ used\ for\ estimation \times volume\ of\ sample\ use\ for\ estimation}$$

Total anthocyanins content was measured by adopting standard methods with slight modifications (Giusti & Wrolstad, 2001; Wijekoon et al., 2011). The total anthocyanin content was calculated based on adopting the following equation:

$$total\ anthocyanin\ content\ (mg/l) = \frac{A \times MV \times DF \times 1000}{\varepsilon \times 1}$$

Where $A = (A_{515} - A_{700})_{pH1.0} - (A_{515} - A_{700})_{pH4.5}$, MV(molecular weight) = 449.2 g/mol for cyanidin-3-glucoside, DF = Dilution factor and ε = 26900 M extinction coefficient, in $L \times mol^{-1} \times cm^{-1}$.

Standard methods were adopted for determining the radical scavenging activities in control and sonicated strawberry juice samples, which was based on DPPH free radical scavenging assay (by using 2,2-diphenyl-1-picrylhydrazyl) (Bhat & Stamminger, 2015a; Blois, 1958). Results obtained were expressed as percentage inhibition of DPPH and calculated by the following formula:

$$\text{Percentage inhibition of DPPH} = \frac{A_{control} - A_{sample}}{A_{control}} \times 100\%$$

Where $A_{control}$ = absorbance of DPPH devoid of added sample extract, and A_{sample} = absorbance of sample with addition of DPPH solution.

2.6. Polyphenoloxidase enzyme activity

The polyphenoloxidase enzyme (PPO) activity in sonicated and control strawberry juice samples was determined by using standard methods with slight modifications (Cheng, Soh, Liew, & Teh, 2007; Ndiaye, Xu, & Wang, 2009). Briefly, samples were individually mixed with 0.2 M potassium catechol buffer (pH6.8, at a ratio of 1:10) and centrifuged (at 6000 rpm; 4 °C for 30 min), followed by collection of the supernatant. Further, catechol