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# Effects of Air-Jet Stem Generator and UP400S Treatment on Vitamin C, Colour and pH of Grapefruit Juice

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*Abstract— Grapefruit juice was subjected to sonication with two different devices: air-jet stem generator of UGAL endowment and UP400S (Hielscher Ultrasound Technology, Teltow, Germany) of UdL, Catalunya, Spain endowment. Air-jet stem generator use 0.1 MPa compressed air as a power source. UP400S with nominal power of 400 W equipped with a 22 mm sonotrode. Samples are treated at 25% amplitude for different times (5, 10, 15, 20, 25 and 30 seconds) at a constant frequency of 24 kHz. Vitamin C, color and pH of grapefruit juice were measured before and after sonication. Air-jet stem generator was demonstrated to be an effective sonic system on grapefruit juice quality parameters.*

*Index Terms— Air-Jet Stem Generator, UP400S, Vitamin C, Colour, Ph, Grapefruit Juice.*

## I. INTRODUCTION

The analysis of any process related to application of ultrasound technology, the first question that arises is to produce ultrasonic vibrations of determining frequency and intensity. Ultrasound is based on the use of sound waves above the threshold of human hearing (>14–16 kHz) that can travel and propagate into a material, providing information about composition and other characteristics depending on the frequency [1].

Ultrasounds have attracted considerable interest in food technology because of its promising in improving the quality and food safety, food processing and preservation. Cavitation is the formation, expansion and implosion of microscopic gas bubbles in the liquid as the molecules in the liquid absorb ultrasound energy [2]. The frequency and amplitude of ultrasound waves, as well as temperature and viscosity of the liquid media influence the degree of cavitation [3].

Ultrasound is reported to have a minimal effect on the quality of fruit juices, such as orange juice, guava juice, blackberry juice and strawberry juice [4]. Grapefruit is one of the most important citrus fruits. This can be consumed fresh or processed in various forms. Grapefruit juice is a popular product and is known to have beneficial effects on human health, including anticancer effects and protection against chronic diseases [5]. The intake of vitamin C reduces the risk of several cardiovascular and neurodegenerative diseases, among others [6]. One of the major nutritional values of grapefruit juice is its vitamin C content [7]. Ascorbic acid is used as an index of the nutrient quality of fruit and vegetable products [8]. Vitamin C (L-ascorbic acid) is one of the most important organic acids in fruits and vegetables, in relation to their nutritional value [9]. Colour is an important attribute related to the visual appeal and the quality of food products [10] and is one of the critical quality factors in grading citrus products [11]. Colour can be one of the important characteristics consumers use when selecting and purchasing products, and the consumer may react negatively to a product if its colour does not meet expectations. Colour, however, is a matter of perception. Different people interpret expressions of colour in many different ways [11]. The objective of this study is to investigate the effects of two different devices of ultrasonic treatment: air-jet stem generator and UP400S.

## II. MATERIALS AND METHODS

### A. Sonication treatment

A photograph of air-jet stem generator is shown in Fig. 1.a). and a photograph of UP400S sonotrode is shown in Fig. 1.b).



Fig.1. Photograph of: a) air-jet stem generator; b) UP400S sonotrode

For operation, air-jet stem generator uses compressed air at supply pressure of 0.1 MPa and provide the production of ultrasonic field with frequency of 24 KHz. Air-jet stem generator dimensions: 70 mm length and 20 mm width. UP400S with nominal power of 400 W equipped with a 22 mm sonotrode and constant frequency of 24 kHz. Grapefruit juice samples (500 ml) were placed in a 1000 ml cylinder glass used as a treatment chamber. Treatment time for both devices was: 5, 10, 15, 20, 25 and 30 seconds all sonication treatments were carried out in duplicate.

#### B. Grapefruit juice samples

Grapefruit juice was obtained from a local supermarket in Lleida, Spain, originated from the same lot and producer.

#### C. Determination of vitamin C by HPLC

For vitamin C determination we used the validated method by [12]. A sample of 2 ml of untreated and sonicated grapefruit juice was mixed with 2 ml of a solution containing 45 g/l 6metaphosphoric acid and 7.5 g/l DTT. After mixing, the samples were filtered in 0.20 µm membrane and introduced into the Waters HPLC System - 600 controller column by manual injector. As mobile phase was used 0.01% sulfuric acid solution with pH 2.6. The flow rate was fixed at 1 ml/min. Detection was performed with a 486 absorbance detector set at 245 NM. Vitamin C identification was made by comparing the retention time and the UV-visible absorption spectrum of samples to the untreated sample. Results were expressed as milligrams of vitamin C per 100 ml of sample.

#### D. Colour analysis and determination of pH

The color of grapefruit juice samples was measured before and after sonic treatment using the Konica Minolta Chroma Meter CR 400-410 with a D65 illuminant based on three color coordinates: L\* (Lightness), a\* (green chromaticity) and b\* (yellow chromaticity). This device was calibrated using the calibration plate: Y=94.0, x=0.3158 and y=0.3322. For each sample we made four readings. Total color difference was evaluated with the following equation [13]:

$$DE^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (1)$$

Colour differences ΔE, were classified as not noticeable (0-0.5), slightly noticeable (0.5-1.5), noticeable (1.5-3.0), well visible (3.0-6.0) and great (6.0-12.0) [14].

Grapefruit juice sample pH determination was performed using Crison micro pH 2000 meter by direct immersion of the electrode in samples. Each sample was measured in triplicate.



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### III. RESULTS AND DISCUSSION

#### A. Vitamin C content

Vitamin C content was studied before grapefruit juice sonication and at 5, 10, 15, 20, 25, 30 seconds treatment time with both devices. The initial vitamin C content of grapefruit juice is 38.47 mg/100 ml. From Fig. 2 it can be concluded that the best vitamin C content was obtained with air-jet stem generator at 10 seconds of treatment. The value is with 4.05 mg/100 ml higher than initial vitamin C content and with 11.39 mg/100 ml than vitamin C content obtained with UP400S at the same treatment time. This positive effect of air-jet stem generator is assumed to be due to effective degassing (oxygen removal) of the grapefruit juice [15].

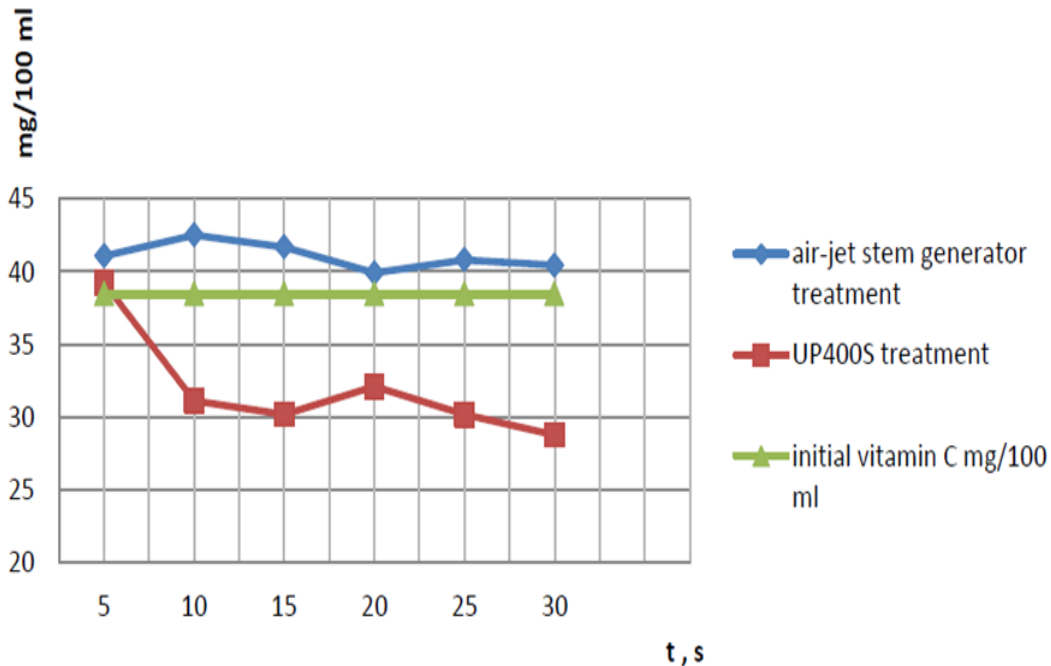


Fig.2. Effect of sonication on grapefruit juice Vitamin C content depending on treatment time

After 5 seconds of treatment with air-jet stem generator we have 41.09 mg/100 ml vitamin C. This value is with 2.63 mg/100 ml higher than initial vitamin C content. At the same treatment time with UP400S the register vitamin C content is higher than initial only with 0.77 mg/100 ml. The lowest vitamin C content 39.91 mg/ 100 ml with air-jet stem generator treatment was obtained at 20 seconds treatment. After another 5 seconds of treatment, vitamin C content increases until 40.81 mg/100 ml grapefruit juice. The correlation between vitamin C loss with UP400S treatment time was significant: from an initial value of 38.47 mg/100 ml to 28.79 mg/100 ml grapefruit juice in 30 seconds. At the same treatment time but with air-jet stem generator we registered 40.44 mg/100 ml vitamin C. Treatment time was the most significant factor influencing vitamin C content

#### B. Colour and pH analysis

The mean values for pH and colour changes in grapefruit juice are shown in Table 1. Sonication of grapefruit juice with air-jet stem generator did not cause significant differences in pH.

pH values of grapefruit juice samples treated with UP400S were significantly influenced by treatment time. After 30 seconds of treatment time grapefruit juice pH decreased until 3.13.

The highest pH of grapefruit juice was observed when the sample was treated with air-jet stem generator for 5 seconds, compared with untreated grapefruit juice.

The colour analysis is slightly noticeable ( $0.5 < \Delta E < 1.5$ ) between untreated grapefruit juice and the ultrasound treated samples:  $L^*$  values remained very close to the untreated sample but the  $a^*$  and  $b^*$  values are different. For all treatments  $a^*$  values decrease and in  $b^*$  value increased compared to untreated grapefruit juice sample. There is no correlation between colour differences  $\Delta E$  value, treatment time and sonic device used in these experiments.



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Table 1. The mean values for pH and colour changes in grapefruit juice

Grapefruit juice	pH**	L*	a*	b*	ΔE
<b>UP400S</b>					
5S	3.16±0.01	31.95±0.08	-1.48±0.03	-0.28±0.06	0.7
10S	3.15±0.00	32.04±0.12	-1.46±0.03	-0.27±0.07	0.6
15S	3.15±0.00	32.33±0.00	-1.50±0.02	-0.16±0.02	0.8
20S	3.14±0.00	32.43±0.00	-1.51±0.02	-0.13±0.01	0.9
25S	3.14±0.00	31.83±0.12	-1.44±0.01	-0.19±0.00	0.7
30S	3.13±0.01	32.23±0.01	-1.49±0.01	-0.12±0.01	0.8
<b>Air-jet stem generator</b>					
5s					
10s	3.24±0.01	32.44±0.02	-1.32±0.03	-0.26±0.01	0.6
15s	3.23±0.01	32.44±0.09	-1.34±0.01	-0.15±0.01	0.8
20s	3.22±0.00	32.36±0.00	-1.29±0.02	-0.25±0.01	0.7
25s	3.22±0.00	32.27±0.00	-1.29±0.02	-0.30±0.02	0.6
30s	3.22±0.01	32.35±0.02	-1.28±0.02	-0.14±0.01	0.7
	3.22±0.00	32.09±0.00	-1.23±0.00	-0.31±0.01	0.5
<b>Untreated grapefruit juice</b>					
	3.22±0.00	32.02±0.02	-1.02±0.00	-0.81±0.00	0

\*\*mean value of three readings; \*mean value of four readings

#### IV. CONCLUSION

The loss of vitamin C in UP400S treatment was significant compared to the air-jet stem generator treatment in which no loss was detected. The grapefruit juice vitamin C content increases with air-jet stem generator treatment after the first 5 seconds of treatment, but maximum value is obtained in 10 seconds of treatment. Meanwhile, grapefruit juice vitamin C content treated with UP400S decreases. It is interesting to note the decrease of vitamin C content with decreasing of pH for UP400S treatment. For increasing vitamin C content in the grapefruit juice air-jet stem generator is very useful for only 10 seconds of treatment. For this research, the samples treated with air-jet stem generator showed better results in vitamin C content compared with UP400S treatment. Air-jet stem generator have minimal effect on the degradation of key quality parameters such as colour and pH in grapefruit juice and rise the content of vitamin C. Liquid products quality improvements can be achieved with ultrasound assisted processing due to degassing of the products [15].

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