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EFFECT OF ULTRASOUND ON THE QUALITY PARAMETERS OF A BANANA, STRAWBERRY AND JUÇARA JUICE BLEND

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ABSTRACT – In this study, the effect of ultrasound processing on the quality parameters of a banana, strawberry and juçara juice blend was evaluated. A central composite rotational design was performed in which the processing power (73.5 to 250 Watts) and time (7 to 36 minutes) were selected as independent variables. The blend was sonicated and then pH, acidity, soluble solids and anthocyanins were evaluated as experimental design responses. It was observed anthocyanins retention of at least 86% in the sonicated fruit juice blends and there was no significant variation in pH, titrable acidity and soluble solids content. Therefore, the ultrasound may become a potential technology for fruit juice blends stabilization.

KEYWORDS: ultrasound; experimental design; physical-chemical characteristics.

1. INTRODUCTION

Juice blend, in accordance to Brazilian legislation (BRASIL, 2009), is the juice obtained by blending fruits, vegetable, fruits and vegetables or the edible parts from vegetables and fruits. The development of fruit juice blends has advantages such as the availability of vegetable products in the off season and the correction of acidity and soluble solids content, allowing the offer of new ready-to-consuming eat products with higher sensory acceptance. Furthermore, the bioactive compounds can be increased, which adds value to the consumer, due to the potentially functional characteristic of the product.

However, before storage the juice blends require processes that stabilize them. In this sense, the heat treatment has traditionally been applied for reducing the microbial load, making this product more stable and suitable for consuming. In turn, it is known that the heat application may cause negative impacts on fruit and vegetable juices such as cooked taste and decreasing of the bioactive compounds contents, as vitamins and phenolics. Ultrasound technology is emerging in the global scenario, being widely studied by the scientific community around world, as an alternative to offer suitable and high quality food products (Abid et al. 2013; Mohideen et al. 2015).

Nowadays, the use of acoustic waves in food processing has been widespread as a non-thermal stabilization technique. The ultrasound, by the cavitation phenomenon, may be used for this purpose by promoting microorganism destruction and enzyme inactivation. However, its effectiveness will depend of various factors such as the physical and chemical characteristics of the product, type of microorganisms present, among others. For this reason, each product demand different processing conditions, requiring specific studies for the complete knowledge of the sonication effects on its microbiological and physical-chemical properties.

Therefore, the objective of this study was to evaluate the effects of ultrasound processing conditions on physical-chemical parameters and anthocyanins content of a banana, strawberry and juçara juice blend.

2. MATERIAL AND METHODS

2.1 Raw-material

Sstrawberry and juçara frozen commercial pulps were used as raw material. Strawberry pulp was acquired in the local market of the Rio de Janeiro city.

Juçara pulp was acquired directly from the processing industry in Rio Novo do Sul, Espírito Santo. It was previously centrifuged in a basket centrifuge (Centrifugal IEC - Model K7165, USA) with a 100 μm nylon filter in order to remove suspended solids and reduce its lipid fraction.

Bananas of the Nanica variety were acquired in the local market of Rio de Janeiro, in ripening stage 6, presenting completely yellow shell, as described by Aurore Parfait and Fahrasmane (2009). The banana pulp processing was performed in horizontal depulper (Itametal, Brazil) provided with polyethylene blades and stainless steel sieve of 1.5 mm.

The fruits were selected taking into account their individual characteristics to obtain a free added sugar functional blend. Thus, the banana pulp was used to confer sweetness, strawberry pulp for balancing the blend pH, reducing the possibility of microbial growth, and juçara pulp to increase phenolic compounds, in particular the anthocyanins.

Juice blend was obtained by mixing pulps in an industrial blender, followed by homogenization (APV homogenizer, Gaulin, USA) at 60 MPa.

2.2 Sonication

The sonication process was conducted in batch in a Hielscher (Teltow, Germany) Industrial Ultrasonic Processor UIP- 1000hd (frequency 20 kHz, variable amplitude 25 lm), Generator 230 volts, transducer IP65 grade with titanium horn, booster B4 1.8 and sonotrode BS2d18. In a jacketed glass reactor coupled to a thermostatic bath (10 °C) 200 mL of the homogenized blend were added. A central composite rotational design was used to evaluate the sonication effect on physical-chemical parameters and anthocyanins content of the juice blend (Table 1). The temperature was recorded in all processes, and described as ΔT the difference between final and initial temperature of the samples.

2.3 Analytical methods

For soluble solids content, pH and titratable acidity standard analytical methods (AOAC, 2005) were used.

Total monomeric anthocyanins contents were quantified by differential pH method (Giusti and Wrolstad, 2001), using cyanidin-3-glucoside as reference, with molar extinction coefficient of 26900 $M^{-1}cm^{-1}$ and molecular weight 449.2 $g.gmol^{-1}$. The extracts were diluted in pH 1.0 and pH 4.5 buffer solutions separately, and after 30 minutes of stabilization, absorbance was read at 510 and 700 nm.

2.4 Experimental design and statistical analysis

It was applied a central composite rotational design for two independent variables, power and processing time (Table 1). The levels of independent variables were selected based on values obtained in preliminary tests. Power (X1) varied between 43.5 and 250 W and processing time, between 2 and 36 minutes. The coded values of independent variables were -α, -1, 0, +1, + α.

Experimental data were analyzed with Statistica 7.0 software, using variance analysis (ANOVA), at $p<0.05$. The physical-chemical properties and anthocyanins contents of the samples were determined in triplicate. Anthocyanin and soluble solids content were analyzed using a response surface methodology design (RSM) and the non-significant parameters, pH and titratable acidity, were not evaluated for RSM studies.

Table 1 – Central composite rotational design for juice blend sonication.

Trial	Time (minutes)	Power (watts)	Time (minutes)	Power (watts)
	Coded variable		Real variable	
1	-1	-1	7	73.5
2	1	-1	31	73.5
3	-1	1	7	220
4	1	1	31	220
5 (CP)	0	0	19	146.8
6 (CP)	0	0	19	146.8
7 (CP)	0	0	19	146.8
8	-1.41	0	2	146.8
9	1.41	0	36	146.8
10	0	-1.41	19	43.5
11	0	1.41	19	250

(CP) – Central point.

3. RESULTS AND DISCUSSION

3.1 Anthocyanins and physical-chemical characteristics

There was a small reduction of anthocyanins in the sonicated juice samples (Table 2), as the retention was superior to 86% of anthocyanins.

According to Sala et al. (1995), the bioactive compounds degradation by sonication occurs due to the cavitation effects on the physical, chemical or biological properties of sample, promoting chemical reactions which may degrade anthocyanin compounds. Furthermore, extreme physical conditions occour during ultrasound processing, such as the temperature and pressure increases, generating free radicals as explained by Portenlänger and Heusinger (1992), as well as polymerization and depolymerization reactions and other mechanisms. However, for Sadilova et al. (2007) the anthocyanins degradation occur, mainly, due to the interaction between free radical and anthocyanin, which promote rupture of the structural rings in these pigments.

Analysis of the data showed that the adjusted model for anthocyanins content was statistically significant at p-value lower than 0.05 ($F_{calculed} = 21.92$ and $F_{listed} = 5.05$). Furthermore, a good correlation coefficient was also obtained ($R^2=0.96$) when Equation 1 was applied,

$$TMA = 12.81 - 0.50x + 0.14x^2 - 0.28y + 0.19y^2 - 0.39xy \quad \text{Eq. 1}$$

in which: TMA is total monomeric anthocyanins; x is the processing time and y is the power.

The behavior of anthocyanins content is shown in Figure 1, where it can be observed that the degradation of these compounds is related to their exposure to power ranging from 140 and 250 watts and processing time higher than 20 minutes.

Figure 1 - Response surface plots for total monomeric anthocyanin content of sonicated juice blend.

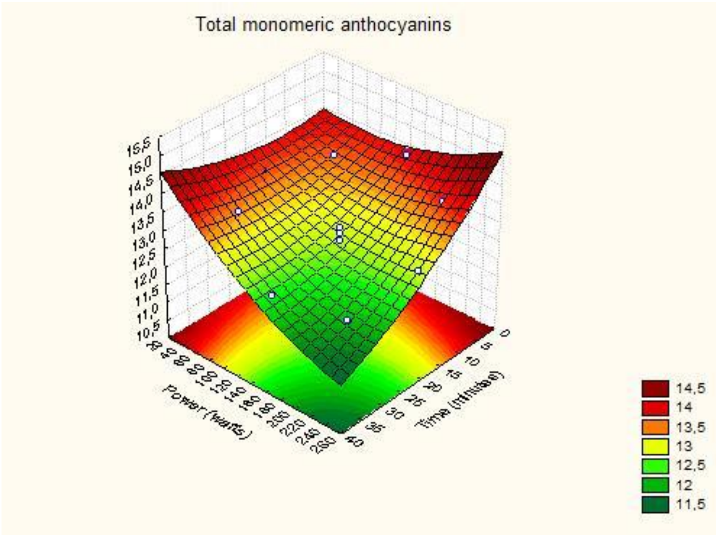


Table 2 - Total monomeric anthocyanins and physical-chemical characteristics of the banana, strawberry and juçara juice blends, before (control) and after ultrasound processing at different conditions.

Trial	TMA¹ (mg 100 g^{-1})	pH	Acidity² (%)	Soluble solids (°Brix)	ΔT (°C)
Control	14.01	4.22	0.44	11.54	-
T1 (73.5 w/ 7 min)	13.54	4.18	0.44	11.38	12
T2 (73.5 w/31min)	13.48	4.21	0.44	11.61	14
T3 (220 w/ 7 min)	13.62	4.22	0.41	11.58	43
T4 (220 w/ 31 min)	12.02	4.24	0.41	11.11	44
T5 (146.8 w/19 min)	12.61	4.15	0.44	11.64	32
T6 (146.8 w/19 min)	12.98	4.37	0.41	11.58	33
T7 (146.8 w/19 min)	12.83	4.19	0.44	11.51	30
T8 (146.8 w/2 min)	13.88	4.22	0.44	11.51	24
T9 (146.8 w/36 min)	12.25	4.32	0.42	11.54	36
T10 (43.5 w/19 min)	13.47	4.19	0.43	11.51	18
T11 (250 w/19 min)	12.84	4.18	0.44	11.78	50

Processing parameters (power/time) in brackets; TMA–Total monomeric anthocyanins; ¹mg of cyanidin-3-glucoside per 100 g; ²grams of citric acid per 100 g.

Pareto chart (Figure 2) also shows the negative time dependence of anthocyanins content, followed by the power processing effect.

Tiwari et al. (2009) reported for sonicated blackberry juice anthocyanins degradation (5%) only at the most drastic studied condition (22.79 $w.cm^{-2}$ for 10 min). Mohideen et al. (2015), in the processing of blueberry juice by ultrasound, carried out in continuous mode at 24 $mL.min^{-1}$ and 93.5 $mL.min^{-1}$, 20 °C and amplitude of 40 and 100%, observed also no significant anthocyanins degradation in the sonicated juices.

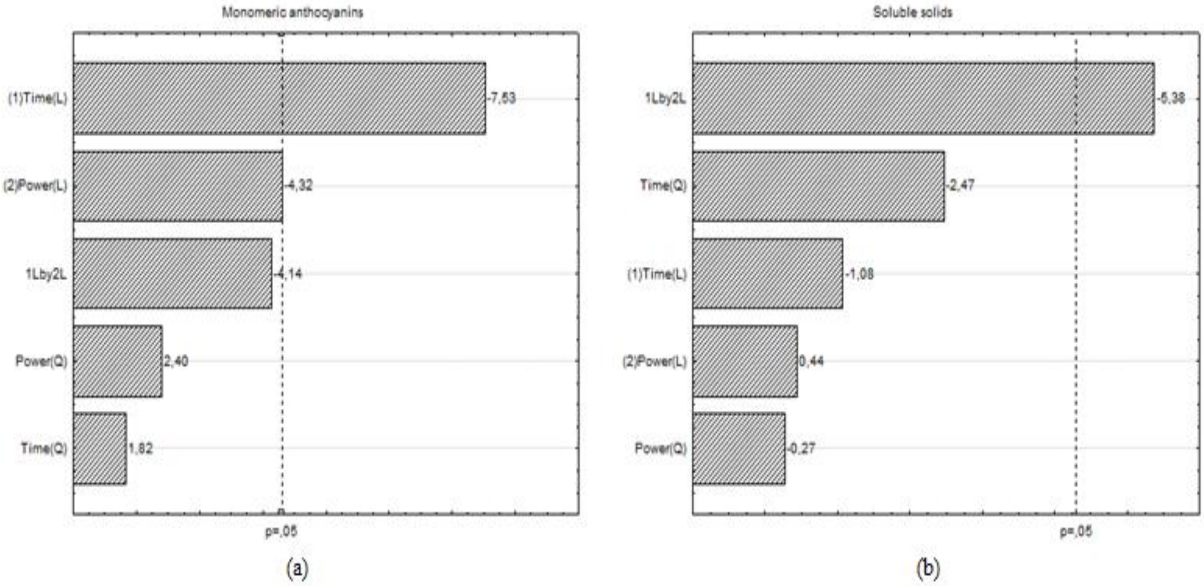
Reported data have shown the anthocyanins stability in different raw materials when sonication was carried out at different processing conditions.

Among the physical-chemical parameters pH, soluble solids and acidity, only the soluble solids content in the juice was significantly affected by the processing parameters as shown in Figure 2. The interaction of time and power presented a significant effect on soluble solids content in the juice blend. However, in practical terms, this effect is not relevant once these results vary between 11.11 and 11.78.

The parameters pH and acidity showed no dependence on power and time ($p> 0.05$). These results are in agreement with data reported by Saeeduddin et al. (2015) that evaluated the effects of ultrasound on physical-chemical parameters of pear juice, as well as with the results reported by Abid et al. (2013), for apple juice.

Regarding the temperature recorded during processes, the highest temperature variation was observed at the higher processing power used. Thus, the increase in processing power is related to temperature increase. Despite the anthocyanins degradation in the juice blend, it may have occurred a synergistic effect of power and temperature. However, the anthocyanin contents observed vary among 12.02 to 13.88. It shows a small degradation these compounds then processing when compared to control sample.

Figure 2 – Pareto chart for the effects of power and process time on total monomeric anthocyanins (a) soluble solids content (b) of sonicated juice blend.



4. CONCLUSION

In the selected range of power and processing time for sonication of fruit juice blend, it was observed a good retention of anthocyanins as well as small changes in physical-chemical parameters.

Thus, ultrasound can become a potential technique for banana, strawberry and juçara juice blend stabilization.

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