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Effect of Heat Treatment on Microbiological Properties of Mixed Tropical Fruits Nectars

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Abstract: The purpose of this research was to evaluate the effect of heat treatment on microbiological properties of mixed nectars based on cashew apple, mango and acerola. Ten different formulations were prepared according to simplex centroid design and subjected to heat treatment at 90°C for 1 min. Samples were collected before and after heat treatment and subjected to microbiological analysis (*Salmonella* sp., yeasts and molds, lactic acid bacteria and coliforms at 35 and 45°C). The mixed nectars were tested regarding to pH and acidity, concerning the relationship between the proportions of pulp and its influence on these results. The pasteurized product presented lower counts of lactic acid bacteria yeasts and molds and all the samples showed no coliform counts and absence of Salmonella 25 g. The formulations with high proportions of acerola pulp showed lower pH and higher acidity butthere was nodirect relationship with the results obtained in the microbiological analysis since, the nectars had similar values of pH and acidity.

Key words: Nectars, heat treatment, microbiology, acidity, acerola pulp, Brazil

INTRODUCTION

It is important to the human health to consume fruit juices since, they are primary sources of nutrients in addition to the fact that they contain several important phytochemicals (Muller *et al*., 2010) that may reduce the risk of various diseases (Caswell, 2009). Therefore, consumers have given particular attention to these products because they contain large amounts of antioxidants such as polyphenols, vitamin C, vitamin E, products of the Maillard reaction and lycopene (Ramadan-Hassanien, 2008), providing pleasant taste and aroma (Maia *et al*., 2007).

The consumers are becoming more rigorous about food quality. This preoccupation has been reflected in the politics of some fruits industries such as the nectars processors, searching to be suitable to quality standards. These industries aim to implement heat treatments that provide good nutrition and small sensory changes to ensure the safety and stability of their products.

Most of the fruits present low pH values being more susceptible to fungi than bacteria attacks and the pasteurization is considered an adequate heat treatment to ensure microbiological stability and to promote food safety (ICMSF, 1998). The microflora that contaminates fruit products usually comes from the raw material quality and from the inadequate washing process besides the sanitary conditions of food handling, equipment and general industrial environment (Santos *et al*., 2008).

Studies about the influence of heat treatment, mainly in the microbiological characteristics of mixed tropical fruit nectars are still scarce.

The study about the effect of heat treatment on microbiological properties of mixed nectars may bring benefits to industries and consumers wishing to consume natural, healthy and flavorful products. Thus, the present study aimed to investigate the influence of heat treatment (pasteurization) on microbiological properties of mixed nectars based on cashew apple, mango and acerola as a contribution to the suitable processing of tropical fruit juices.

MATERIALS AND METHODS

Formulations and experimental design: Pasteurized and frozen cashew apple, mango and acerola pulps, produced by a local industry at Pacajus/CE were used in the current study.

Ten formulations were prepared with various concentrations of cashew apple, mango and acerola pulps from the simplex centroid design, totaling 35% of pulp (Table 1).

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Table 1: Formulations of the mixed nectars

	Pseudo components (%)			Original components (%)		
Formulations	Cashew apple	Mango	Acerola	Cashew apple	Mango	Acerola
1	90.00	5.00	5.00	31.5	1.8	1.8
2	5.00	90.00	5.00	1.8	31.5	1.8
3	5.00	5.00	90.00	1.8	1.8	31.5
4	47.50	47.50	5.00	16.6	16.6	1.8
5	47.50	5.00	47.50	16.6	1.8	16.6
6	5.00	47.50	47.50	1.8	16.6	16.6
7	33.30	33.30	33.30	11.7	11.7	11.7
8	61.67	19.17	19.17	21.6	6.7	6.7
9	19.17	61.67	19.17	6.7	21.6	6.7
10	19.17	19.17	61.67	6.7	6.7	21.6

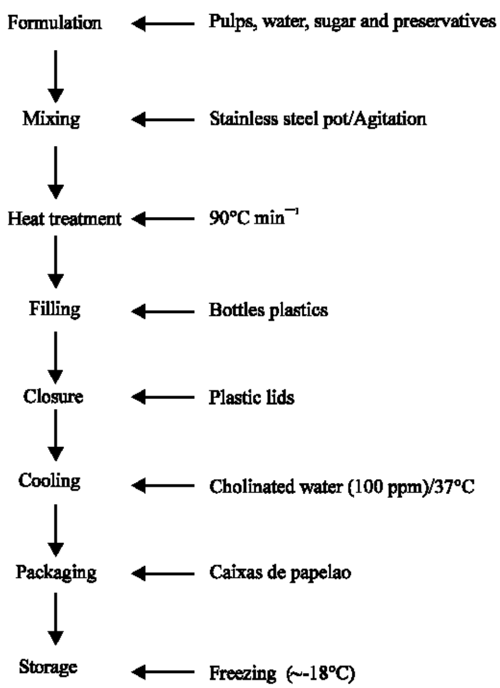

Fig. 1: Processing of mixed nectar of cashew apple, mango and acerola pulps

The concentration of soluble solids was fixed at 11°Brix, through mass balance. After mixing, each formulation was divided into two parts, one being submitted to heat treatment 90°C for 1 min (pasteurization) followed by hot filling in 100 mL polyethylene bottles (Fig. 1) and the other part of the samples (not submitted a heat treatment) was transferred to a polyethylene bottles. The formulations were kept frozen (-18°C) until the time of analysis.

Microbiological analysis: It was examined Salmonella/ 25 g, Coliforms at 35 and 45°C (MPN/g), lactic acid bacteria (CFU/g) molds and yeasts count (CFU/g), according to the method described by Silva *et al*. (2001).

Chemical analysis: It were realized the pH, acidity and soluble solids analysis, according to IAL (Instituto Adolfo Lutz) (2008). In the representation of the adjustment of response values which are the chemical parameters, it used the linear, quadratic and cube models in terms of pseudo components. The statistical significance of the data was determined by analysis of variance, 5% level of confidence using the software Statistica version 7.0.

$$Y = b'_1x'_1 + b'_2x'_2 + b'_3x'_3 \quad (1)$$

$$Y = b'_1x'_1 + b'_2x'_2 + b'_3x'_3 + b'_1b'_2x'_1x'_2 + b'_1b'_3x'_1x'_3 + b'_2b'_3x'_2x'_3 \quad (2)$$

$$Y = b'_1x'_1 + b'_2x'_2 + b'_3x'_3 + b'_1b'_2x'_1x'_2 + b'_1b'_3x'_1x'_3 + b'_2b'_3x'_2x'_3 + b'_1b'_2b'_3x'_1x'_2x'_3 \quad (3)$$

Where:

Y = Estimate the response of apparent viscosity and behavior and consistency index
b' = Coefficients of equation
x' = Proportion of pseudo components (cashew apple- x'_1, mango x'_2 and acerola- x'_3)

RESULTS AND DISCUSSION

Microbiological analysis: *Salmonella* sp. and coliforms at 35 and 45°C <3MPN mL^{-1} were not detected in tested formulations (Table 2). Considering the low pH and high acidity of these products, they do not present ideal conditions for the development of these microorganisms (Maia *et al*., 2007).

For the analysis of lactic acid bacteria, it was observed a higher score in the unpasteurized samples, confirming the effectiveness of heat treatment used to reduce these microorganisms. The formulations 2-5 showed a small increase in the counting of molds and yeasts after heat treatment.

Amaro *et al*. (2002) evaluated the effect of heat treatment on the microbiological characteristics of passion fruit pulp, noting count reduction of yeasts and molds in pasteurized samples, similar to the results observed by Teixeira *et al*. (2006) for soursop pulp.

Chemical analysis: It was not observed a direct relationship between pH and acidity of the nectar with the results obtained in the microbiological analysis, despite the nectar with a higher proportion of the acerola pulp presented lower pH and higher acidity.

This can be explained due to the fact that nectars had similar values of pH and acidity. The soluble solids content presented higher value in pasteurized samples as

Table 2: Microbiological analysis for unpasteurized and pasteurized mixed nectars based on cashew apple, mango and acerola

Nectar	Coliforms at 35°C (MPN mL^{-1}) N	Coliforms at 35°C (MPN mL^{-1}) P	Coliforms at 45°C (MPN mL^{-1}) N	Coliforms at 45°C (MPN mL^{-1}) P	Lactic bacteria (CFU mL^{-1}) N	Lactic bacteria (CFU mL^{-1}) P	Yeasts and molds (CFU mL^{-1}) N	Yeasts and molds (CFU mL^{-1}) P	*Salmonella* sp. N	*Salmonella* sp. P
1	<3	<3	<3	<3	3.4×10^2	<10	<10	<10	A	A
2	<3	<3	<3	<3	7.1×10^2	2.0×10	<10	1.0×10	A	A
3	<3	<3	<3	<3	2.5×10^2	1.0×10	<10	1.0×10	A	A
4	<3	<3	<3	<3	3.0×10^2	3.0×10	1.0×10	2.0×10	A	A
5	<3	<3	<3	<3	2.3×10^2	<10	1.0×10	2.0×10	A	A
6	<3	<3	<3	<3	2.9×10^2	1.0×10	<10	<10	A	A
7	<3	<3	<3	<3	2.4×10^2	<10	<10	<10	A	A
8	<3	<3	<3	<3	2.9×10^2	<10	<10	<10	A	A
9	<3	<3	<3	<3	4.9×10^2	<10	1.0×10	<10	A	A
10	<3	<3	<3	<3	4.8×10^2	<10	<10	<10	A	A

N = Unpasteurized; P = Pasteurized; A = Abscence/25 mL; MPN = Most Probable Number; CFU = Colony Forming Units

Table 3: Results of pH, total titratable acidity (gcitric acid/100 g) and soluble solids of pasteurized and unpasteurized mixed nectar of cashew apple, mango and acerola

Nectar	pH N	pH P	Total acidity N	Total acidity P	Soluble solids N	Soluble solids P
1	3.90±0.02	4.51±0.04	0.24±0.00	0.27±0.32	11.33±0.06	12.40±0.44
2	3.83±0.02	4.53±0.04	0.29±0.02	0.27±0.37	11.37±0.06	12.05±0.39
3	3.66±0.03	4.08±0.24	0.29±0.07	0.29±0.24	11.70±0.00	12.07±0.45
4	3.82±0.00	4.46±0.12	0.27±0.37	0.26±0.25	11.33±0.06	13.30±1.65
5	3.77±0.03	4.42±0.09	0.27±0.36	0.26±0.33	11.37±0.06	12.22±0.49
6	3.68±0.04	4.37±0.12	0.29±0.37	0.29±0.21	11.40±0.00	11.93±0.31
7	3.80±0.02	4.43±0.08	0.31±0.03	0.27±0.21	11.40±0.00	12.00±0.31
8	3.82±0.00	4.48±0.05	0.31±0.02	0.26±0.13	11.40±0.00	12.27±0.19
9	3.78±0.03	4.42±0.09	0.27±0.37	0.26±0.11	11.30±0.00	11.83±0.25
10	3.68±0.04	4.37±0.06	0.29±0.37	0.29±0.14	11.57±0.06	12.03±0.21

Means followed by standard deviations. N = Unpasteurized, P = Pasteurized

expected. During the heat treatment the evaporation of water presented in the nectar occurs, resulting in higher soluble solids content (Table 3).

For pasteurized and unpasteurized nectars, the pH results obtained significant adjustments ($p\leq0.05$) for the linear, quadratic and cubic models. The cubic model was chosen for analysis of this parameter to provide higher deter mination (R^2).

The pasteurized formulations presented pH ranging from 4.37-4.53 (Table 3). Pinheiro evaluating different formulations of nectar based on cashew apple and acai pulps, noted that the formulations with higher content of cashew apple pulp showed higher pH values.

The formulations subjected to the heat treatment presented higher pH values when compared to formulations that have not undergone heat treatment with values ranging from 4.08-4.53. With the increasing of acerola pulp proportion, a reduction of the pH value for all formulations tested (Fig. 2a and b) was observed. Evaluating the coefficients of the equations, it was found that the interaction between the cashew apple and mango pulps and acerola and cashew apple pulps contributed to the decrease in pH of pasteurized nectar (Fig. 2b). For non-pasteurized nectars, the interaction between the acerola and cashew apple pulps and cashew apple, mango and acerola pulps influenced the reduction of this parameter. The mango pulp was the one that showed the influence to increase the pH of the nectars. The levels of titratable acidity were adjusted to a cubic model for the nectars juices (Fig. 3a) and linear model to the pasteurized nectars (Fig. 3b), these models showed significant adjustments ($p\leq0.05$). The formulations that shown higher levels of the acerola pulp showed higher results for acidity as compared to formulations that showed higher levels of cashew apple and mango pulps.

Analyzing the coefficients of equations (Fig. 3a and b), it was found that with increasing proportion of cashew apple pulp in the mix, there was a decrease in acidity. The acerola pulp showed the greatest influence on increasing in the acidity of nectars. For unpasteurized nectars, the combination of the pulps of cashew apple, mango and acerola resulted in decrease in acidity of these products.

The pasteurized and unpasteurized formulations presented similar results for acidity Maia *et al.* (2004) evaluated the effect of processing on tropical pineapple juice, reporting that the samples subjectedto heat treatment (pasteurization) showed higher acidity when

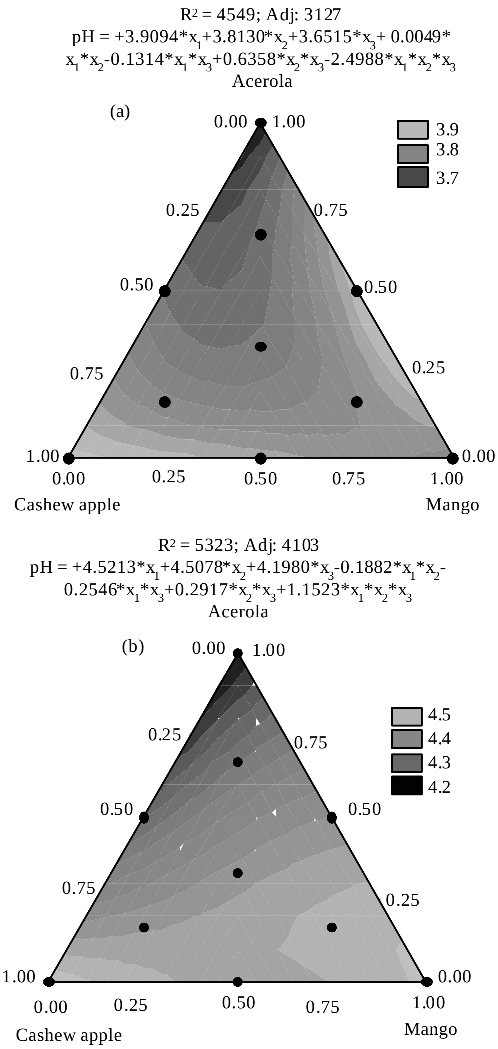

Fig. 2: Ternary diagrams surface response for pH analysis. (a) unpasteurized nectars (b) pasteurized nectars

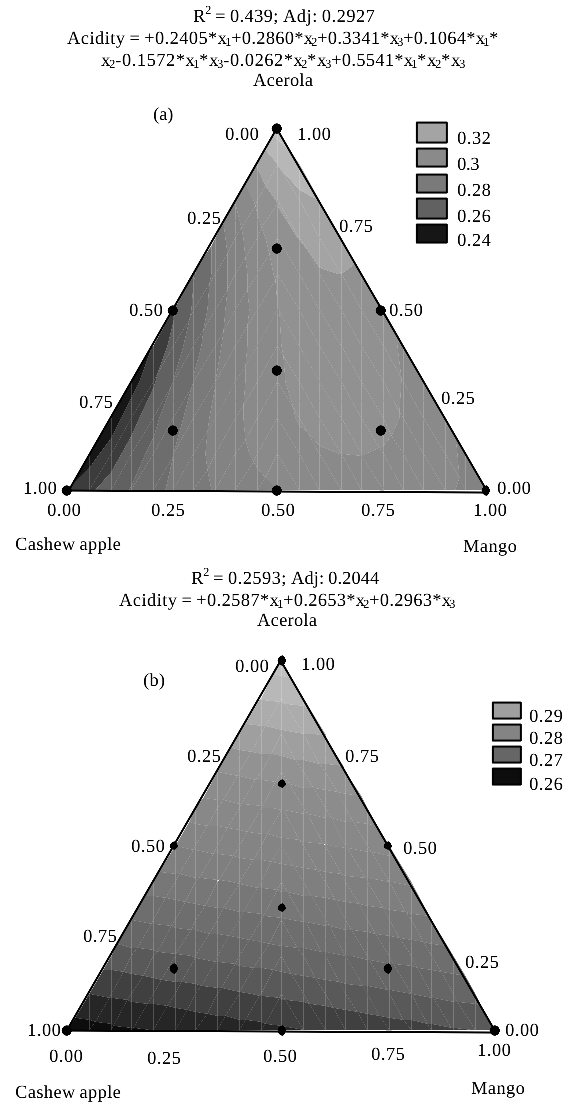

Fig. 3: Ternary diagrams surface response for acidity analysis. (a) unpasteurized nectars (b) pasteurized nectars

compared to the samples not pasteurized, a result similar to that observed in this study, for the nectar 1. As observed, the data reported in the literature show a decrease in pH value with the application of the heat the samples studied in this study. However, it should be noted that such behavior was observed in nectar made with just one fruit. For the samples studied in this research, mixed drinks have parameters to consider especially the contribution of each fruit with his constituents, despite the loss by evaporation due to heat treatment provided the chemical constituents, probably due to interactions or treatment, a contrary behavior to that obtained for chemical degradation which may account for pH values found even higher than those determined for samples not pasteurized.

CONCLUSION

The heat treatment applied to the mixed nectar based on cashew apple, mango and acerola resulted in reduction of microbial load.

The heat treatment applied resulted in an increase in pH and there was not observed significant changes to tiratable acidity.

There was observed a direct relationship between pH and acidity of the nectar (the proportions of the different pulps) with the results obtained in the microbiological analysis.

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