Coconut water processing using ultrafiltration and pasteurization

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ABSTRACT

Green coconut water is traditionally consumed fresh, directed from the fruit at production regions. In order to allow its consumption in other regions, its industrialization demands a conservation process able to maintain its physic-chemical and sensory characteristics. Pasteurization is the main technique used for beverage preservation and microbiological safety. On the other side, membrane technology has been studied for conservation of beverages, due to their low temperature process conditions. The objective of this study was to evaluate the ultrafiltration and pasteurization processes for conservation of coconut water regarding the fresh product characteristics. Fresh coconut water was acquired from the local market in Rio de Janeiro city, immediately after extraction and cold to 15°C. Ultrafiltration was conducted in a plate and frame unit composed of 20 kDa membranes. Process was carried out at 5 bar and 15°C. Permeate flux was measured along the process. Pasteurization was performed in a tubular pasteurizer at 96°C for 20 s. Samples were collected for determination of physic-chemical parameters, microbiological quality and sensory acceptability. Average permeate flux in ultrafiltration was 13 L/hm^2. Both processes were effective for reducing enzyme activity although decreasing total phenolics and soluble solids. Acidity and pH of processed waters were similar to fresh one. Microbiological analyses have shown that both processes provided safe products. On the other side, there was a significant difference in the acceptability of ultrafiltered water in relation to the fresh one. The obtained results indicate that both processes may be adequate for processing coconut water, although they need to be optimized regarding their sensory characteristics.

Keywords: tropical fruits; fresh drink; membrane technology; conservation processes

INTRODUCTION

Green coconut water is a very pleasant drink, usually consumed fresh at production regions as along the Brazilian coast and many urban cities. It is traditionally consumed directed from the fruit although this practice presents some barriers related to transportation and storage of the fruits. As the water represents just 25% of the fruit weight to discard the coconut waste is still a problem in the cities [1, 2].

It is a product of high consumption in Brazil and that begins to have an international demand due to its appeal as healthy and salt replenishing. Its sweet and astringent flavor is also attractive to consumers.

The use of adequate processes for conserving coconut water make possible to extend its shelf-life and, consequently, to optimize the fruit use; it can also contribute to formalize its commercialization and reduce the intermediate actors that make the product more expensive; besides of contributing to job generation and to improve the green coconut agribusiness.

In this way, the aim of the coconut water industrialization must be to extending the shelf-life preserving their characteristics and facilitating their consumption out of the producers regions.

The green coconut water naturally contains oxidative enzymes in its composition. The water inside the fruit is sterile but when it is extracted and exposed to air oxygen it becomes subjected to oxidation besides of microbial contamination.

Currently, pasteurization is the main technique used for beverage preservation and microbiological safety. Some studies have been made to evaluate the effect of pasteurization conditions on the inactivation of oxidative enzymes, peroxidase and polyphenoloxidase in coconut water as it has already been verified the activity of thermal resistant enzymes in such product [3, 4, 5].

Therefore, it is important to establish a preservation process that does not present a negative effect on the composition and sensory characteristics of coconut water. In this sense, membrane technology is potentially attractive due to their mild processing conditions. When using ultrafiltration membranes, the permeate

fraction can be considered as cold pasteurized as microorganisms are retained by the membrane [6]. The use of ultrafiltration for coconut water processing has been successfully done [7].
In the present study the objective is to compare ultrafiltration and pasteurization processes concerning the preservation of coconut water regarding the fresh product characteristics.

MATERIALS & METHODS

Raw material
Fresh green coconut water.

Experimental procedure
Fresh coconut water was acquired from the local market in Rio de Janeiro city. The coconut water was extracted, immediately cold to 15°C and then filtered for removal of suspended solids. Membrane process was conducted in semi-pilot scale in a plate and frame ultrafiltration unit composed of 20 kDa flat sheet membranes. Process was carried out in batch mode, at 5 bar and 15°C. The permeate flux was measured along the process. Pasteurization was performed in a tubular pasteurizer at 96°C for 20 s. Samples of fresh, ultrafiltered and pasteurized coconut water were collected for the determination of physico-chemical and biochemical parameters, microbiological quality and sensory acceptability.

Analytical methods
Soluble solids content, pH and acidity were determined in the three samples according to AOAC [8]. Total phenolic compounds were determined by the Folin-Ciocalteu assay proposed by Singleton and Rossi [9]. The results were expressed in mg of gallic acid/100g of sample.
The polyphenoloxidase and peroxidase enzymatic activity was measured following the method proposed by Campos [5] and adapted by Abreu & Faria [4], using catecol for the polyphenoloxidase determination and guaiacol and hydrogen peroxyde for peroxidase. One unit of enzyme activity means a 0,001 variation of absorbance per minute per mL of sample.
Microbiological parameters of coliforms at 45°C, *Salmonella* detection, mold and yeast and psicrotrophyc bacteria counting were determined according to APHA [10].
The sensory evaluation was carried out in the Sensory Laboratory of Embrapa Food Technology. The subjects were recruited from students and workers from administrative and technical staff of Embrapa and selected according to their liking and consumption frequency of coconut water. They should drink coconut water at least "once in a while", being that approximately 23% of them presented frequency of consumption of one or more times a week. Consumers (80) evaluated the three samples regarding to "overall liking" acceptability on a hybrid hedonic scale, varying from 0-disliked extremely to 10-liked extremely [11]. They were 42 women and 38 men, and their ages ranged mainly between 18 and 45 years. The samples were monadically served at refrigeration temperature (6±2°C), codified with 3 digit numbers in individual booths under white light. The presentation order followed a balanced complete block design. For the acceptability test, the samples were presented to consumers accompanied by water for cleaning the palate. Statistical analysis were performed by ANOVA and significant differences among samples were assessed using the Fisher (LSD) test ($p<0.05$) in XLSTAT software.

RESULTS & DISCUSSION

Average permeate flux in the ultrafiltration processing of coconut water was 13 L/hm^2, in the same range of previous works conducted in a similar equipment [7]. Permeate flux behavior is shown in Figure 1 where it is possible to observe its stabilization after few minutes of processing.
The physico-chemical data are presented in Table 1.
Acidity, pH and soluble solids content of ultrafiltered and pasteurized waters were very close, being verified a small reduction in soluble solids when comparing to fresh coconut water. The soluble solids reduction in ultrafiltered water (10%) is in the same range of the sugars reduction verified by Reddy et al. [12] when filtered coconut water in a 0.2 µm cellulose nitrate microfiltration membrane.
It can be observed that ultrafiltration and pasteurization were both effective for reducing the enzyme activity of coconut water although decreasing total phenolics. The enzyme activity reduction after a heat processing has been reported by other authors [3, 13] although the presence of residual isoenzymes with thermal resistance could interfere in the product stabilization.

Microbiological analyses have shown that both processes provided safe products with coliforms at 45°C less than 3 MPN/g, absence of *Salmonella* spp. in 25 g and counting of psicrotrophyc bacteria less than 1.0×10^1 CFU/g and mold and yeast , attending the Brazilian legislation requirements for processed coconut water [14].

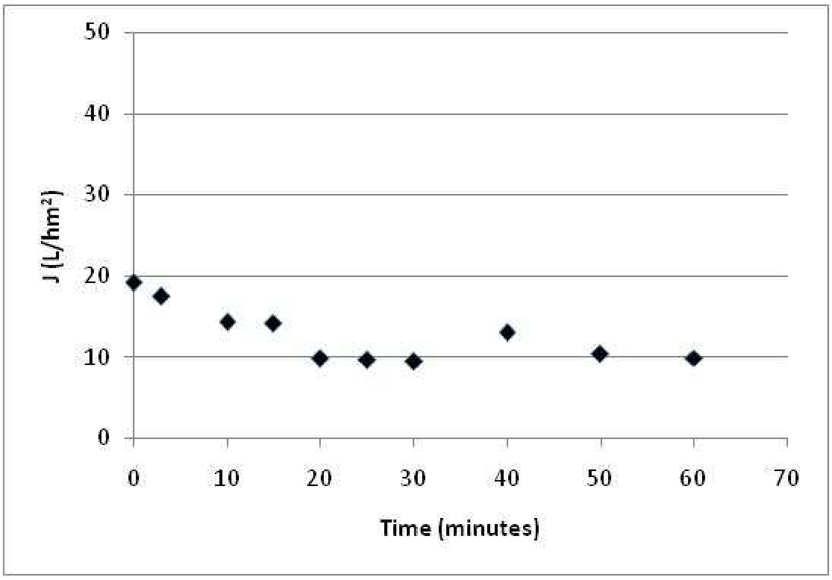

Figure 1. Permeate flux of coconut water during ultrafiltration in 20 kDa polymeric membranes.

Table 1. Characteristics of fresh, ultrafiltered and pasteurized coconut water

Parameter/Sample	Fresh	Ultrafiltered	Pasteurized
Soluble solids (°Brix)	5.6	5.0	5.2
pH	4.89	4.86	4.89
Acidity (g/100g)	0.06	0.05	0.05
Total phenolics (mg/100g)	3.65	1.09	1.33
Peroxidase activity (U/mL)	0.320	0.002	0.002
Polyphenoloxidase activity (U/mL)	0.649	0.026	0.026

After consumers' evaluation, a good acceptance (over to 68%) was observed for all coconut water samples. However, there was a significant difference in the acceptability of ultrafiltered water in relation to the other ones. Figure 2 shows that the frequency of acceptance scores (scores > 5.0) for "overall liking" of fresh coconut water was higher than those obtained for the pasteurized and ultrafiltered coconut water. The results show that 69%, 88% and 90% of the consumers liked ultrafiltered, pasteurized and fresh coconut water, respectively. In addition, the fresh and pasteurized coconut water was preferred to the ultrafiltered one, showing significant difference ($p < 0.05$) between the global averages (Table 2).
The greater acceptance for the fresh coconut water may be linked to how the participants usually consume coconut water. Approximately 15% of the consumers said that they consume coconut water at cafeterias, 27% at home and 81% outdoors (beaches, parks, etc.), being mainly consumers of fresh (fruit) coconut water (96%) against 20% and 12% of UHT (Ultra High Temperature) processed and pasteurized (and cold) ones, respectively. In a study of conservation of green coconut water by membrane filtration, Magalhães et al. [7] showed that 94% of the consumers who tasted the ultrafiltered coconut water liked the product. However there was no directly comparison with fresh coconut water. Nogueira et al. [15] verified the preference among three commercial UHT processed and fresh coconut water, concluding that the fresh one had greater acceptance by consumers. The obtained results in this work probably indicate that the reduction of soluble solids, total phenolic and other compounds in ultrafiltered water may cause its loss of flavor, decreasing its acceptability scores.

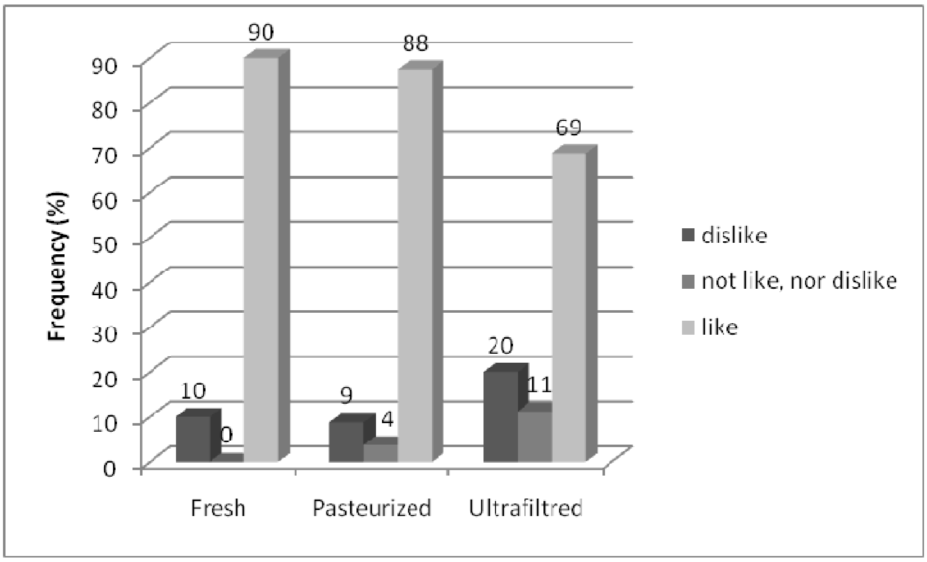

Figure 2. Frequency (%) of hedonic scores for fresh, pasteurized and ultrafiltered coconut water.

Table 2. Average acceptance scores for coconut water

Sample	Overall liking
Fresh	8.1a
Pasteurized	7.7a
Ultrafiltered	6.5b

Different letters within column indicates significant ($p<0.05$) differences on Fisher (LSD) test

CONCLUSION

The obtained results indicate that both processes may be adequate for processing coconut water, although ultrafiltration needs to be optimized regarding its effect on sensory characteristics of the product.

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