Effect of isostatic high-pressure on chemical and physical characteristics of cashew tree gum

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ABSTRACT – The isostatic high-pressure processing (HIP) is considered a non-thermal process. This technology is arousing a growing interest of: i) food industries that aim a product with greater commercial potential; and, ii) consumers that seek more nutritionally rich foods. However, there is a need to understand the effect of this technology on food ingredients, e.g. gums. This study investigated the effect of isostatic high-pressure technology on chemical and physical characteristics of cashew tree gum (CTG). The analysis included monosaccharide composition, linkage analysis, molecular weight, flow behavior and differential scanning calorimetry. CTG solutions at pH 3.2 and 3.7 (20%, m/v) were processed (100-600 MPa, 10 min., at 25°C). The processing promoted a slight molecular weight increasing. However, it did not affect the consistency or flow behavior indexes, and no tendency was identified in linkage analysis. Therefore, these results suggest that cashew tree gum would not decharacterize the final product after the process.

KEYWORDS: hydrostatic high pressure; high pressure processing; polysaccharide.

1. INTRODUCTION

The agribusiness of cashew tree (Anacardium occidentale L.) has a high economic importance to Northeast of Brazil, being the cashew nut, the most profitable product. The cashew apple also has an expressive commercial importance, e.g. juices and jams. However, it is frequently wasted (Vidal e Pereira, 2015). Then, the cashew tree gum (CTG) appears as a byproduct obtained from the raw exudate of the trunk of cashew tree, that, at this time, does not present any commercial value, but has potential application for food and beverage (Porto e Cristianini, 2014), pharmaceutical (Paula et al., 1998) e chemical industries (Lima et al., 2002).

The CTG is a heteropolysaccharide containing mainly carbohydrates (98%) (Porto e Cristianini, 2014; Porto et al., 2014), with monosaccharide composition of galactose (69%), arabinose (10%), uronic acid (10%), glucose (8%) and rhamnose (3%) (Pereira-Netto et al., 2007). Besides the carbohydrates, the CTG also contains 1 to 3% of proteins (Porto e Cristianini, 2014; Porto et al., 2014).
Polysaccharides are often modified by physical, chemical and/or biochemical processes (Towle e Whistler, 1993). Among them, the physical ones are the most advantageous once they generally do not generate waste nor use toxic reagents (Porto et al., 2015).

The pH is an important physical-chemical characteristic of substances in solution. It defines the solubility, adsorption and absorption capacity, reactivity, conformational structure, of biopolymers. The isoelectric point of CTG is around pH 3.2 and its natural pH is approximately in pH 3.7, where the polymer is slight negatively charged (Porto et al., 2014). According to pH, the gum structure will be more or less open which can influence the degree of alteration in the process.

The isostatic high-pressure (HIP) was introduced to food industry as a non-thermal process based on two principles: i) Le Chatelier, the reactions are favored by volume reduction caused by pressure increasing (Butz e Tauscher, 2002); ii) Pascal, the pressure is transferred to the whole product at the same time (Rasanyagam et. al., 2003).

Nowadays, the HIP has been applied on food constituents to understand what is happening with each substance when a whole food system is processed. Several works studied the effect of HIP on polysaccharides (Blaszczak et al., 2007a; Blaszczak et al., 2007b; Roeck et al., 2009; Mateos-Aparicio et al., 2010). Among the more mentioned effects are functionality increasing of dietetic fibers (Mateos-Aparicio et al., 2010), reduction of pectin methoxylation degree (Roeck et al., 2009), increase of flavor adsorption capacity of starch (Blaszczak et al., 2007a) and retrogradation reduction of starch (Blaszczak, 2007b). However, there are not studies that evaluate the effect of HIP on chemical, physical and technological aspects of CTG. Therefore, this work aimed to evaluate the effect of HIP on chemical and physical characteristics of CTG.

2. MATERIAL AND METHODS

2.1. Material

The raw exudate was donated from Embrapa Tropical Agroindustry – Ceará – Brazil. The exudate was reduced to pieces of 1-4 cm and a dispersion in distilled water (10%, m/m) was prepared at room temperature in a magnetic stirrer for 24 h. The dispersion was filtered and centrifuged to remove impurities. After, the supernatant was precipitated in ethanol 96 °GL at 16 °C in a proportion of 2:3 (gum dispersion:ethanol). The supernatant was discarded. The precipitate was dried in forced air oven and milled (A11 Basic - IKA™, Germany) to obtain the powder.

2.2. Methods

2.2.1. HIP process

A dispersion of CTG (15%, m/m) in distilled water was prepared and kept under agitation until complete solubilisation at 60 °C. After that, the dispersion was maintained at 6 °C for 12 h. The pH was modified to 3.2 and 3.7 and the samples placed in a flexible plastic bag (LDPE-Nylon-LDPE, TecMaq, Brazil), and processed at 100, 200, 300, 400, 500 and 600 MPa at 25 °C for 10 min. The samples were freeze-dried and milled to obtain the modified CTG. Control samples (pH 3.2 and 3.7) were produced following the same steps of modified gum without HIP process. The process was performed in duplicate.

2.2.2. Size exclusion chromatography (SEC)
The determination of molecular weight was performed by size exclusion chromatography with refractive index detector. Pullulans (Polymer Laboratories, United Kingdom) of 11880, 22800, 112000 and 212000 Da were used as analytical standards to obtain the calibration curve of $R^2 = 0.9933$. The analysis was performed in duplicate.

2.2.3. Monosaccharide composition and linkage analysis

The neutral monosaccharides, acid monosaccharides and linkage analysis were determined according to Pettolino et al. (2012), York et al. (1986) and Pettolino et al. (2012), respectively. The analysis was performed in duplicate.

2.2.4. Rheology

The flow behavior of CTG solutions was determined according to Porto et al. (2015) in triplicate.

2.2.5. Differential Scanning Calorimetry (DSC)

The DSC was performed in a DSC equipment (TA Instruments, 060 WS, Thermal Analyzer, Shimadzu, Japan) in duplicate. Aluminum plates were weighed and the sample added (5 mg). The plates were covered, pressed and analyzed. Initial temperature: 30 °C; Heating rate: 10 °C/min; Final temperature: 400 °C (1 min); and, $N_2$ flow: 30 mL/min.

2.2.5. Statistical analysis

The similarities and differences of results were investigated by Analysis of Variance (ANOVA) and Tukey Test using the software Statistica® 7 (Statsoft, EUA).

3. RESULTS AND DISCUSSION

3.1. Size exclusion chromatography (SEC)

The results of SEC are presented in Table 1. CTG presented as a mix of polysaccharides/heteropolysaccharide with different sizes (Figure 1).

<table>
<thead>
<tr>
<th>Monosaccharide linkages (% mol)</th>
<th>pH 3.2</th>
<th>pH 3.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100 MPa</td>
<td>600 MPa</td>
</tr>
<tr>
<td>Peak 2</td>
<td>4.40 x 10^4A</td>
<td>4.40 x 10^4A</td>
</tr>
<tr>
<td>Peak 3</td>
<td>2.09 x 10^4A</td>
<td>2.09 x 10^4A</td>
</tr>
<tr>
<td>Terminal-L-arabinofuranosyl→1→2-L-arabinofuranosyl</td>
<td>2.82 ± 0.54^A</td>
<td>2.50 ± 0.41^A</td>
</tr>
</tbody>
</table>

Table 1 - Molecular weight (Da) and monosaccharide linkages (% mol) of modified and non-modified cashew tree gum at pH 3.2 and 3.7.
The monosaccharide composition of CTG consisted of: galactose (73.9 mol%), glucose (12.93 mol%), arabinose (4.25 mol%), rhamnose (2.31 mol%), fucose (1.59 mol%), and glucuronic (1.31 mol%) and galacturonic acid (3.59 mol%). The galactose was the main monosaccharide found in CTG and (1→6) the linkage more presented with exception of CTG processed at 600 MPa at pH 3.2 (1→3,6). All the glucose of CTG seem to be in the terminal position. Although, there are some
differences among processed and non-processed samples, no association between the results of linkage analysis and MW promoted by HIP was observed.

### 3.3. Rheology

The Figure 2 presents the flow behavior of non-processed and processed CTG at pH 3.2 and 3.7 under shear rate ($\gamma$) of 0.1 to 300 s$^{-1}$. The higher is the shear rate, the higher is the shear stress. Furthermore, the nonlinear curves characterize the samples as pseudoplastic fluid. All the samples presented the same apparent viscosity, indicating the HIP was not able to modify the rheological properties of CTG.

**Figure 2.** Flow behaviour (25 °C) of CTG solutions (10%, m/v) non-processed and processed by IHP from 100 to 600 MPa at pH 3.2 and 3.7. $\sigma$ and $\gamma$ are shear stress and shear rate, respectively.

### 3.4. Differential Scanning Calorimetry (DSC)

The DSC thermogram of CTG presented large peaks characterizing amorphous samples. Three endotherm peaks were identified: i) desolvating; ii) melting; and, iii) complete decomposition, according to described by Okoyey et al. (2012). The same thermogram profile was found for all samples and only the desolvating enthalpy was possible to measure. There were no differences ($p>0.05$) among the desolvating enthalpy measured: control (pH 3.2 – 135.06 ± 8.87 J/g; pH 3.7 – 134.37 ± 6.55 J/g), 100 MPa (pH 3.2 – 141.41 ± 5.77 J/g; pH 3.7 – 141.08 ± 9.03 J/g) and 600 MPa (pH 3.2 – 134.66 ± 8.02 J/g; pH 3.7 – 144.92 ± 6.67 J/g). Therefore, the HIP process was not able to modify the calorimetric properties of desolvating of CTG.

### 4. CONCLUSION

The HIP process did not promote modification of CTG at pH 3.2 or 3.7 when processed up to 600 MPa at 25 °C for 10 min. However, the results suggest the use of CTG as an additive for food systems processed by HIP, since CTG will not be modified avoiding a mischaracterization of the final product.

### 5. ACKNOWLEDGMENTS

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6. REFERENCES

Blaszczyk, W., Misharina, T. A., Yuryev, V. P., & Fornal, J. (2007). Effect of high pressure on binding aroma compounds by maize starches with different amylose content. LWT – Food Science and Technology, 40, 1841-1848.


