Biosynthesis of xanthan gum from fermenting potato peels extract: Influence of sucrose supplementation on yield and apparent viscosity

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Abstract

Several residues and carbohydrate-rich effluents have been studied as a possible alternative in the substitution or implementation of the traditional cultivation medium of xanthan gum, helping in the management of these residues and, consequently, reducing fermentation costs. This work studied the extract obtained from potato peels for xanthan gum production by fermentation with or not sucrose supplementation. Xanthan gum yield ranged between 2-4 g L^{-1}, and a linear relationship between the amount of added sucrose and gum produced was observed. In addition, the peak of gum production with higher viscosity was able to be anticipated with the sucrose supplementation, from 72 to 24 h (with the 5% of sucrose in comparison with the control condition). The maximum viscosity was 950 mPa.s, a result higher than many published papers that use residues as culture medium for xanthan production.

Keywords: residue, viscosity, *Xanthomonas*, fermentation

1. Introduction

According to the World Resources Institute (WRI), 41,000 tons of food are wasted annually in Brazil, which puts the country among the top ten countries that lose more food resources (EBC 2016).

In human food, potato (*Solanum tuberosum* L.) is consumed *in nature* or such form of chips, pre-fried frozen, pre-cooked, lyophilized or in starch form, among other products (Mota et al. 2016). The Brazilian Institute of Geography and Statistics – IBGE presented a production of potatoes in Brazil in 2018 around 3.85 million tons and Fernandes et al. (2008) estimated an annual discard of more than 300 thousand tons of potato peels, which leads to a serious environmental impact. These residues, traditionally used for animal feed, soil fertilizer or as raw material for biogas production, can be directed to advanced technologies for the use of potato peels in food processing, phyto-pharmaceutical and biosynthetic industries, increasing the value added from waste (Wu 2016).

Xanthan gum is produced by Gram-negative strains of *Xanthomonas campestris* and are characterized as a water-soluble extracellular heteropolysaccharide with unique rheological properties, such as suspending, stabilizing, thickening and emulsifying agent in the food, cosmetics, pharmaceutical, paper, paint, textile and oil industries (García-Ochoa et al. 2000; Ozdal & Kurbanoglu 2018).

This study evaluates the potentiality of potato peel extract as a substrate for xanthan gum production and the sucrose supplementation influence on gum fermentation and apparent viscosity. In addition, it is an attempt to add value to a food waste while reduces the environmental impact, which does not suffer any kind of treatment and disposal.

2. Materials and Methods

The potato peel extract, collected from street vendors of potato chips, was washed and stored in a freezer until the treatment to avoid degradation process.

The strain *Xanthomonas campestris* pv. *manihotis* ISBF 1182 was obtained from the Biological Institute of São Paulo. The inoculum was cultured in yeast malt medium, incubated at 28 °C for 24 h in an orbital shaker at 200 rpm.

Fermentation broth, composed by potato peel crushed (1:2, potato peel:distilled water), was supplemented without and with addition of 2% and 5% (w v^{-1}) of sucrose, 0.01% (w v^{-1}) urea and 0.1% (w v^{-1}) potassium phosphate, and pH adjusted to pH 7.0, distributed in 250 mL Erlenmeyer flasks and sterilized at 121 °C for 15 min.

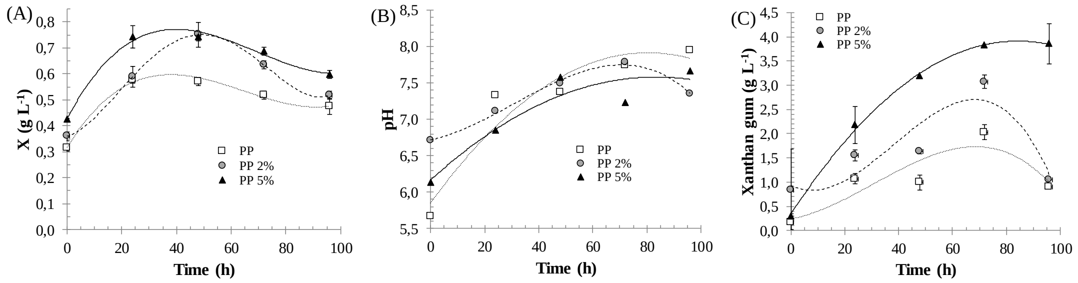
The fermentation was conducted in an orbital shaker at 200 rpm for 96 h, collecting samples every 24 h for cell growth, pH and gum production (product). The polymer was recovered by precipitation from the supernatants by adding ethanol (1:2) followed by drying at 50 °C.

Rheological characteristics were evaluated in a Brookfield DV-II + Pro viscometer, with concentric cylinders and a software Rheocalc and B.E.A.V.I.S. (Brookfield Engineering Advanced Viscometer Instruction) program. Rheological data were fitted to the Oswald-de-Waele or power law model, $\mu = K\,(\gamma)^{n-1}$, where μ is the apparent viscosity, K is the consistency index, γ is the shear rate and n is the flow behavior index.

3. Results and Discussion

The cell growth of *Xanthomonas* occurred until 24 h, remaining in stationary phase until 48 h, with subsequent death phase (Figure 1A), and carbon supplementation affected positively microbial development. The initial pH in the fermentation was around 6, an optimal pH value for bacterial polysaccharide synthesis (García-Ochoa et al.

2000), and it was slightly increased until 7.5-8.0 during the fermentation (Figure 1B).



PP – potato pulp extract, PP 2% – potato pulp extract + 2% sucrose and PP 5% – potato pulp extract + 5% sucrose.

Figure 1. Behavior of the kinetic variables in submerged fermentations of potato peel extract with and without sucrose (2% and 5%). (A) Cell growth, (B) pH, (C) Xanthan gum production.

The production of xanthan gum was increased according to sucrose addition, having a gain of 50 and 100% in the production yield when the broth was supplemented with 2 and 5% of sucrose, respectively (Figure 1C), when reaches 3.84 g L^{-1}. Mesomo et al. (2009) reached 36 g L^{-1} from cheese whey, an effluent with nitrogen and carbon balance very suitable for xanthan gum production, suggesting more studies for C:N relation.

The quality of the gums produced were validated by measurements of the rheological properties through apparent viscosity analysis in the aqueous solutions of 1% (w v^{-1}) gum, at 28 ºC. Xanthan gums presented a pseudoplastic behavior, typical characteristic for polymer solutions of microbial polysaccharides (García-Ochoa et al. 2000; Cacik et al. 2001; Rao et al. 2003), exhibiting values of fluid behavior index below 1 ($n < 1$) (Table 1). The viscosities in the shear rate at 25 s^{-1} and temperature of 25 °C presented values much higher than the results found by Brandão et al. (2010) with solution 2% of gum produced by cassava serum, which reached 41.79 mPa.s as maximum viscosity value. Silva et al. (2009), in a shear rate of 12.2 s^{-1} at 25 ºC, with an aqueous solution of 3% of gum produced with cheese whey obtained a maximum viscosity of 57.39 mPa.s and, in the presence of 0.1% (w v^{-1}) of KCl, 266.64 mPa.s. These results indicate that the quality of the gum obtained may be promising and new studies involving parameters optimization such as culture aging, stirring, supplementation of salts and nitrogen, temperature and different pHs can significantly increase the values found.

Table 1. Rheological parameters characterizing the pseudoplasticity of the biopolymer synthesized in potato peel as substrate.

Time (h)	PP				PP 2%				PP 5%			
	C (%)	*k* (mPa.s)	*n*	R^2(%)	C (%)	*k* (mPa.s)	*n*	R^2(%)	C (%)	*k* (mPa.s)	*n*	R^2(%)
24	0.5	982.4	0.26	99.4	1.0	2,384	0.19	99.0	1.0	3749	0.13	99.7
48	0.5	685.5	0.31	99.4	1.0	2,297	0.22	99.3	1.0	1671	0.26	99.3
72	1.0	970.6	0.20	99.5	1.0	1,152	0.27	99.5	1.0	2196	0.23	99.5
96	0.5	682.1	0.31	99.0	0.5	756.4	0.31	99.2	1.0	1755	0.25	99.5

PP – potato pulp extract, PP 2% – potato pulp extract + 2% sucrose and PP 5% – potato pulp extract + 5% sucrose.

4. Conclusions

The potato peel extract fermentation of xanthan gum, presenting values of the ratio gum/substrate similar to most of the waste-using published data in the production of this polysaccharide. Supplementation with sucrose increased the yield of xanthan gum by 50 and 100% when 2 and 5% sugar were added, respectively. The quality (viscosity) of the gum solution was proportional to the amount of sugar added, showing that the combination between potato extract and sucrose was important.

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