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ETHANOL PRODUCTION FROM SPENT COFFEE GROUND HYDROLYSATE

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Introduction. The ethanol production by fermentation has received large importance in the last few years due to its increased demand as fuel and complement to gasoline. Ethanol production by fermentation of agro-industrial wastes is particularly very attractive because of their low cost and abundance, and non-competition with foodstuffs (1). Spent coffee ground (SCG) is the solid residue obtained during the treatment of coffee powder with hot water or steam for the instant coffee preparation. SCG is a sugar-rich residue generated in large amounts every year, but that is practically unused (2).
The purpose of the present study was to evaluate the ethanol production using SCG as raw material. Assays were performed with the hydrolysate in the following forms: original (as produced), detoxified with activated charcoal or with ion exchange resin, concentrated, and concentrated and supplemented with nutrients.

Methodology. A sugar-rich hydrolysate was produced from SCG according to previously optimized reaction conditions, which consisted in using a liquid/solid ratio of 10 g/g and 100 mg H_2SO_4/g dry matter, at 163 ºC for 45 min (2). Detoxification of the hydrolysate with activated charcoal was performed by adding 1 g of charcoal per 40 g of hydrolysate (at pH 2.0), followed by stirring at 150 rpm, 45 °C during 1 h. Detoxification with ion exchange resin (a strong cation type IRN-77), was performed by adjusting the hydrolysate pH to 5.5 and then mixing the resin at a ratio of 1 g to each 5 mL, followed by agitation for 1 h at room temperature. These hydrolysates were also used as fermentation medium after concentrated to increase the original sugar content (≅ 40 g/L) in twofold, and supplemented or not with the nutrients (g/L): yeast extract (3.0), $(NH_4)_2HPO_4$ (3.0), and $MgSO_4x7H_2O$ (1.0). Fermentations were performed in 250-mL Erlenmeyer flasks containing 100 mL of medium inoculated with an initial cell concentration of 1 g/L, at 30 °C, 200 rpm for 29 or 48 h (not concentrated and concentrated hydrolysates, respectively). *Saccharomyces cerevisiae* was the yeast strain used for sugars conversion to ethanol.

Results and Discussion. Sugars present in original untreated SCG hydrolysate (mainly mannose and galactose, and lower amounts of glucose and arabinose) were converted to ethanol with 100% efficiency (Table 1), but about 25% of the total sugars remained unconverted. Detoxification of the hydrolysate with activated charcoal or with ion exchange resin did not improve the sugars consumption by the yeast, and gave slightly lower ethanol yield than the untreated hydrolysate, suggesting that the treatments (mainly IRN treatment) removed compounds of importance for the yeast metabolism. Toxic compounds (particularly phenolic compounds) were removed from the hydrolysate through the detoxification procedures; however, it was concluded that the toxic compounds present in SCG hydrolysate were not at enough high concentrations to inhibit the yeast metabolism.

Table 1. Fermentation parameters obtained during the SCG hydrolysate conversion to ethanol by *Saccharomyces cerevisiae*.

Hydrolysate	Et (g/L)	SC (%)	$Y_{P/S}$ (g/g)	$Y_{P/X}$ (g/g)	$Y_{X/S}$ (g/g)	Qp (g/Lh)	η_P (%)
Original (as produced)							
Untreated	13.86	75.1	0.51	3.62	0.12	0.69	100
Charcoal treated	13.22	77.9	0.49	3.63	0.12	0.66	95.5
IRN treated	11.30	73.6	0.48	2.64	0.14	0.57	93.4
Concentrated							
Untreated	27.08	89.9	0.33	3.22	0.10	0.93	65.4
Charcoal treated	20.78	89.7	0.33	2.92	0.11	0.72	65.5
IRN treated	16.31	78.0	0.31	4.69	0.06	0.34	60.0
Concentrated and supplemented							
Untreated	23.80	90.7	0.28	3.01	0.09	1.19	55.6
Charcoal treated	23.68	90.7	0.27	2.52	0.10	1.18	52.8
IRN treated	19.05	90.0	0.26	2.92	0.08	0.95	50.7

Et: ethanol; SC: sugars consumption; $Y_{P/S}$: ethanol yield factor; $Y_{P/X}$: ethanol production per cell mass; $Y_{X/S}$: cell yield factor; Q_P: ethanol productivity; η_P: ethanol efficiency.

Sugars consumption was improved from concentrated hydrolysates, and the ethanol productivity was also increased (except for the IRN treated), but the ethanol yield was affected. Supplementation with nutrients had only a positive effect on fermentation of IRN treated hydrolysate, confirming that this treatment removed nutritional sources from SCG hydrolysate.

Conclusion. SCG hydrolysate obtained by dilute acid hydrolysis is a suitable fermentation medium for use on ethanol production by *S. cerevisiae*. This hydrolysate does not require detoxification, concentration and supplementation with nutrients to be efficiently fermented to ethanol, which are important aspects in terms of economy of the process.

References.

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