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TECHNICAL FEASIBILITY OF ETHANOL PRODUCTION FOR FUEL FROM SORGHUM (*Sorghum bicolor* L. Moench) USING ACID AND ENZYMES

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Introduction. The production of ethanol for fuel in Brazil is made commercially only from sugar cane. Other starchy raw material is used for alcoholic fermentations as beer and whiskey (1). The widespread cultivation of sugar cane has been criticized for characterizing monoculture. With the experience of the enzymatic hydrolysis of starch for other biotechnological products could be possible to use other starchy crops to produce ethanol (2). Among many potentially starchy raw materials available for alcohol production highlight the grain sorghum. The sorghum crop has been recommended for regions where may occur the phenomenon of drought during the rainy season, when the rains are expected regularly. The Central West region of Brazil falls in these risk regions (3). Among the available types of sorghum the grain one represent a potential to be studied as ethanol raw material, by using the starch of the grain panicle. Acid and enzymatic process is possible to use. The enzymatic hydrolysis occurs in two stages. The viscosity of cooked starch granules is reduced by using an α-amylase, following by the saccharification when dextrins are converted in sugars. After the hydrolysis the worth is fermented in similar way of the sugar cane juice. The purpose of this research was to evaluate the production of ethanol from the sorghum (*Sorghum bicolor* L. Moench) grains using acid and enzymatic process.

Methodology. The experiment was performed in the Technology Center for Agribusiness, Mato Grosso do Sul, Brazil. A single 10 kg batch Biomatrix seeds was used. The sorghum was milled to facilitate hydrolysis. The granulometry was established by using sieves between 4.000 and 0.425mm with a bottom >0.045 mm. The grounded grains were used to prepare the worth by enzymatic and acid process. The suspensions for both processes of hydrolysis were 50% of sorghum grain in water. The **acid hydrolysis** used 150 ml 1M HCl per kg of sorghum. The suspension was heated in autoclave (97°C/30min). The **enzymatic hydrolysis** used Novozymes® enzymes on the same suspension. The amount of enzyme was calculated on the sorghum starch content (30% by dry weight): Thermamyl (3ml/kg), SacchZyme (0.7 ml/kg) and AMG (2ml/kg). The acid or enzyme worth was adjusted to pH 4.5 and 12 ° Brix with chemically untreated water and inoculated with 1% of fresh yeast. The fermentation was done at room temperature (25 to 30^{o}C). The fermentations were followed by Brix on hand refract meter, and sugar by density, reducing sugar (RS) and total reducing (TRS) and pH. At the end of fermentation alcohol content was determined by distillation and read with alcoholmeter.

Results and Discussion. The grounded sorghum had 90% of particles between 0.60 and 1.00 mm. In the **acid hydrolysis** initial Brix was on average 17.3 and 19.0, RS was 19.0 and TRS was 26.0g/l. Both the sugars (RS and TRS) decreased very little with fermentation time which could be explained by the formation of non-fermentable sugars, the TRS reduced more than RS to around 13 g/l. The expected theoretical ethanol yield would be a half of the Brix or 6 v/v but it was measured 2v/v. The sugar formation for **enzymatic hydrolysis** was higher than for **acid hydrolysis** and different for the saccharifying enzymes. AMG values for RS was 37 and TRS 26.0g/l. SacchZyme values for RS was 29 and TRS 42 g/l. After the fermentation the AR and ART dropped to 4 and 6 for AMG and 5 and 6 for SacchZyme. Brix fell to 2 for both. The alcoholic degree was near 6 v/v for both.

Conclusions. The acid hydrolysis yield lower alcohol fermentation (2% v/v) than for enzymatic hydrolysis (6% v/v). In enzymatic hydrolysis the best results were obtained for SacchZyme using a half of the concentration of AMG. The Brix value was not the best parameter to evaluate the alcoholic yield. The alcohol graduation were higher than expected by Brix or sugars reduction, even considering the residual sugar, showing that more research must be spent for starch worth fermentations for ethanol.

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