Bioconversion Of Cassava– A Potential Source Of Energy In India

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Abstract

An attempt has been made to produce high grade alcohol from cassava flour which could be utilized as 20:80 mixture (20 Alcohol to 80 gasoline) for automobiles. The methods standardized for the saccharification and fermentation of cassava for maximum production of alcohol are discussed in this paper.

Introduction

The production of alcohol from starch is not new in the realm of fermentation technology. With the emergence of the energy crisis, the production of ethanol for motor fuel has received a new impetus and cassava is being considered as an important carbohydrate source. Experts on energy have pointed out the importance and practical application of biomass as a source for the production of alcohol (Mc Cann an Prince, 1978 and Scheller, 1977). The market price of cassava is linked with the price of rice in India. With the introduction of high yielding strains and also as a result of better agronomic practices, grain production in India has increased considerably thus, lowering the price of cassava. Diversified utilization of cassava is therefore, an important factor besides the urgent need for production of ethanol to meet the energy requirements of the country.

The hydrolysis process and the utilization of an efficient low cost saccharifying agent are of paramount importance in the fermentation of cassava. An attempt was made therefore, to utilize various saccharifying agents available in fermenting cassava for power alcohol production. The results obtained are summarized and presented in this paper.

Materials and Methods

Three saccharifying agents, viz. acid, malt and one commercial enzyme were used for hydrolysis of starch.

Acid hydrolysis. One hundred grams of cassava starch was mixed with 0.05 N, 0.1 N and 0.2 N Hcl and the total solids were adjusted to 20%. The amount of starch to acids was adjusted to a ratio of 1:5. The acidified starch was saccharified in an autoclave at 120°C at different hour lengths. The hydrolysate was then filtered and the clear acid liquor was neutralized with 10% ammonium hydroxide to a pH of 5.1. The yeast strain *Saccharomyces cerevisiae* (Strain No. 34, Hafe Bank, Munchen) was multiplied and inoculated at the rate of 1.0 – 1.1 g centrifuged yeast/100 ml hydrolysate. The fermentation was allowed to continue for 48-50 hrs at 28-30°C. The fermented hydrolysate was distilled and the specific gravity of the distillate was measured to determine the yield of alcohol. Corrections were also made for moisture content in the cassava meal.

Malt hydrolysis. The starch was gelatinized as mentioned earlier. Different concentrations of malt viz. 5%, 10%, 15% and 20% were added and the pH was adjusted to 5.1. After overnight incubation the mash was saccharified at 45°C for 2 hours and fermented at 25°C for 48 hours. The yield of alcohol was recorded following the same procedure adopted for acid hydrolysis.

Enzyme hydrolysis. One hundred grams of cassava starch was gelatinized in an autoclave at 121°C for 1 hour with 250 ml water. The gelatinized starch was further diluted with 250 ml cold water. In order to prevent mash infection 0.75 ml of formalin was added and the pH was adjusted to 5.1.

The saccharification was carried out in a laboratory mash kettle at 45°C with a constant stirring at 200 rpm for different periods of time, i.e., 24 hours, 48 hours and 72 hours. The enzyme amylo-glucosidase obtained from a private company was added at the rate of 2% to the mash kettle after the pH adjustment. The mash was filtered after the saccharification. The specific gravity in P of the hydrolysate was measured using a plate sacchorometer. The hydrolysate volume was adjusted to a constant volume of 200 ml and fermented with the yeast strains used for the previous experiments for 48 hours, at 28-30°C. The fermented mash was filtered and the alcohol volume calculated as mentioned earlier.

Results and Discussion

The degradation of starch and cellulose to low molecular weight fermentable sugars have been well known and hydrochloric acid and sulphuric acids are commercially used for the saccharification of starch. Prior to the introduction of commercially produced enzymes in 1958 the hydrolysis of starch to glucose or other simpler sugars was entirely by acid. The formation of secondary reversion reactions which sets a limit to the yield of glucose and higher inorganic salts due to pH adjustments are the main limitations of acid hydrolysis. But the better alcohol yield and the better economy involved makes this method attractive. Table 1 (Figure 1) shows the alcohol yield under different concentrations of hydrochloric acid. Of the two commercial acids used, the hydrochloric acid is more effective and gives smooth saccharification and higher yield of alcohol. 0.05

N acid was found to be insufficient and saccharification was not satisfactory. The optimum concentration of acid was found to be 0.1 N and further increase in the concentration of acids did not increase the saccharification rate. These results are in agreement with those of previous works (De-Meneses, 1978).

The amylolytic enzymes used in the biological saccharification can be obtained from several sources. Glucose and other simple sugars are hydrolyzed by δ and β amylase and amyloglucosidase. The sources of these enzymes and their potential application for industrial uses have been reviewed (Allen and Dawson, 1975; Sherwood, 1966 and Wurzburgand Szymanski, 1970). Barley malt is an important source of these enzymes and 4 concentrations of malt were tried at different temperatures and pH. The optimum temperature and pH for the hydrolysis was found to be 45^{o}C and 5.1 respectively. Table 2 (Figure 1) shows that out of the 4 concentrations of malt tried, maximum yield of alcohol was at 15 percent concentration of malt.

Several investigators have reported preparation of insolubilized amylo-glucosidase and δ - amylase and their use in the production of glucose syrups (Bachler, et al., 1970; Linko, et al., 1975; Park, 1974; Park, 1975 and Sherwood, 1966). The process of conversion of cassava starch into alcohol by using a fungal enzyme preparation from submerged culture to hydrolyze the starch into sugar have been well documented (Teixeira, 1950). Alcohol yield after saccharification of starch using commercial grade amyglucosidase at different periods of time is given in Table 3 (Figure 1). There was no significant difference in alcohol yield when the starch was treated with the commercial enzyme preparation at different periods of time.

The results also show that the alcohol yield of acid hydrolyzed starch was always higher than that of the malt and enzyme hydrolized starch though it has been reported that acid hydrolysis will render low yields of alcohol due to the partial degradation of the sugars by acid. Because of the low cost and the ready availability of acids in India, acid hydrolysis of cassava for alcoholic fermentation seems to be promising for the time being. However, work on the conversion efficiency of the dual-enzymes and acid-enzymes as reported earlier (Sinclair, 1965; Ana C., 1978; Aschengreen, 1975; Ewing, 1967) for the economic production of alcohol is in progress at the Institute.

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Table 1. Saccharification of cassava starch and the yield of alcohol under different concentrations of hydrochloric acid

Normality	Original gravity plato	Final gravity plato	Mash quotient	% convertable solids	Alcohol yield ml/100 g of cassava starch
0.05	15.92	9.30	41.20	88.00	20.90
0.10	16.40	1.30	93.0	85.00	44.70
0.20	16.30	1.00	100.0	94.00	37.60

Table 2. Saccharification of cassava starch and the yield of alcohol under different concentrations of malt

Malt %	Original gravity plato	Final gravity plato	Mash quotient %	Alcohol yield ml/100g cassava starch
5	9.30	3.75	60.33	17.00
10	13.70	2.50	82.00	32.00
15	12.50	0.99	101.00	32.00
20	14.80	0.99	100.20	32.00

Table 3. Saccharification of cassava starch and alcohol yield using commercial amylo-glucosidase

Time of hydrolysis	Original gravity plato	Final gravity plato	Mas quotient %	Alcohol yield ml/100g of cassava starch
24 hrs	13.80	0.002	99.98	33.00
48 hrs	13.75	0.002	99.97	34.70
74 hrs	13.80	0.002	99.98	35.00

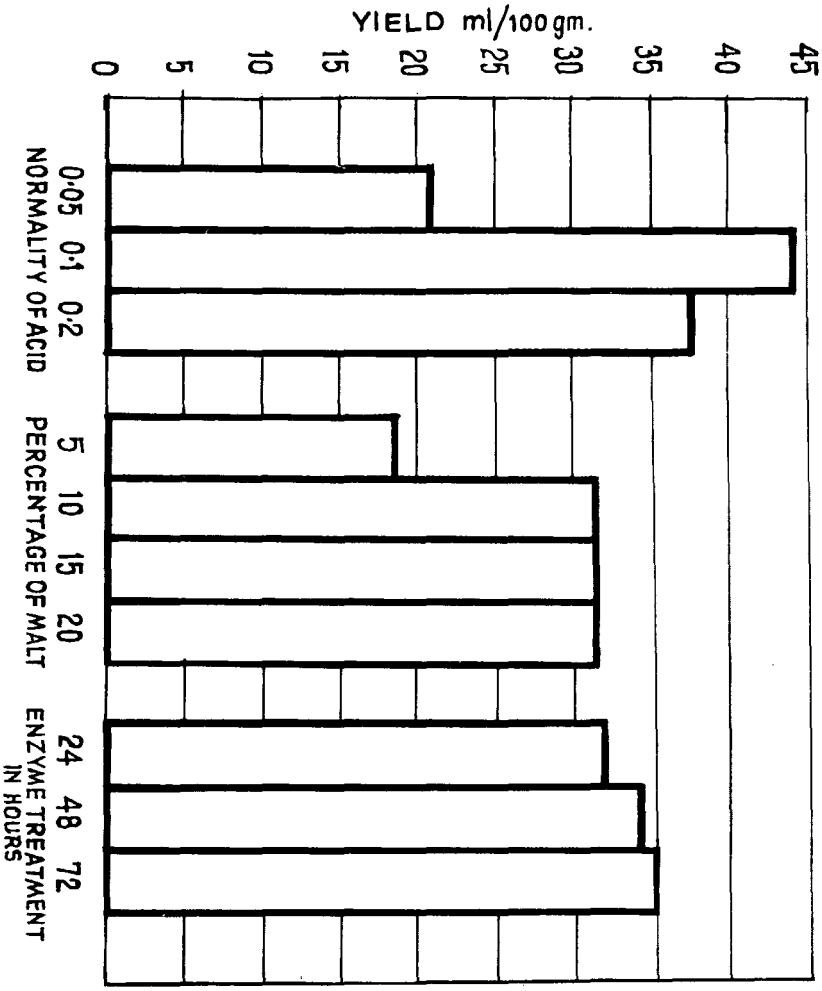

Figure 1. Saccharification of cassava starch and the yield of alcohol under different treatments.