Cost Analysis of Substrates Used for Ethanol Fermentation by *Saccharomyces Cerevisiae*

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ABSTRACT

Ethanol fermentation is a biological process which converts sugars such as glucose, fructose and sucrose intro cellular energy, producing ethanol and carbon-dioxide as a byproduct. It is a metabolic process that converts sugar to different products like acids gases or alcohol is known as fermentation. Metabolism is the set of life –sustaining chemical transformations within the cells of living organisms. These enzyme-catalyzed reactions allow organisms to grow and reproduce, maintain their structures, and respond to their environments. A huge number of substrates are used for ethanol production namely, grapes, apples, pears, honey, potatoes, rice, sugarcane, glucose, cassava etc. With the increasing demand of ethanol for numerous uses, research needs to be done to compare the different routes for ethanol production economically. Cost comparison for three such substrates is done in this study. The substrates chosen for the study are glucose, Jaggery and sugarcane molasses. After the experiments and cost analysis it was found that jaggery is the most cost effective for alcohol production and molasses is better than the other two for producing yeast.

Keywords: *- Glucose, Jaggery, Sugarcane Molasses, cost analysis, Fermentation*

1. INTRODUCTION

Ethanol from renewable resources has received considerable attention over the years as a transportation fuel. The economics of fuel-ethanol production are significantly influenced by the cost of raw materials used in the production process. Ligno-cellulosic biomass, such as agricultural and forestry residues, has been identified as a potential feedstock in view of its ready availability and low cost. [1]

If a fermentation process is to yield a product at a competitive price, the chosen micro-organism culture should give the desired end-product in predictable and economically adequate quantities. Raw material should be as cheap as possible and utilized efficiently. When a batch process is operated, the growth cycle should be as short as possible to obtain the highest yield of product and allow for maximum utilization of equipment. [2] In a review of a number of processes, Nyiri and Charles concluded that four basic components contributed to the process cost in the following decreasing order: raw materials, fixed cost, utilities and labour. [3] So in this study the cost analysis for three raw materials (substrates) glucose, jaggery and sugarcane molasses is done.

2. MATERIALS AND METHODS

2.1 Procedure for Yeast and Alcohol Estimation

The yeast estimation is done with the help of a UV Spectrophotometer. The wavelength used for the analysis is 600 nm. A device called as alcoholmeter is used for alcohol estimation. The device belongs to the series of hydrometer family, which works on the concept of specific gravity. We need to simply dip the alcoholmeter in the solution to get the alcohol percentage. A Gay Lussacs Alcoholmeter is used in the procedure.

2.2 Cost of Raw Materials Used in the Fermentation Process

The cost of the raw materials and chemicals used is taken from the website of sigma-aldrich [4] and are shown in the table below

Table-1: Pricing of component per kg and per gm

component	price/kg	price/g
glucose	3330	3.33
jaggery	50	0.05
molasses	85	0.085
peptone	27874	27.874
yeast extract	22108	22.108
(NH4)2SO4	9765	9.765
MgSO4	11194	11.194
KH2PO4	8976	8.976

Table-2: composition in production medium for each substrate

	substrate (g/l)		
material	glucose	jaggery	molasses
sugar	76.5	230	115
peptone	10	10	10
yeast extract	5	4	4
(NH4)2SO4	2	1	1
MgSO4	5	5	5
KH2PO4	2	1	1

Table 2 shows the composition used for the fermentation process for each substrate. All the chemicals are added to enrich the media used.

The fermentation is carried out for 4 days. The alcohol estimation for each of the substrate is carried. Also the numbers of yeast cells are calculated at the end of each day. The alcohol percentages are compared for the daily as well as the maximum value that is at the end of day 4.

3. RESULTS AND DISCUSSION

3.1 Comparison between substrates for biomass (yeast cells) production

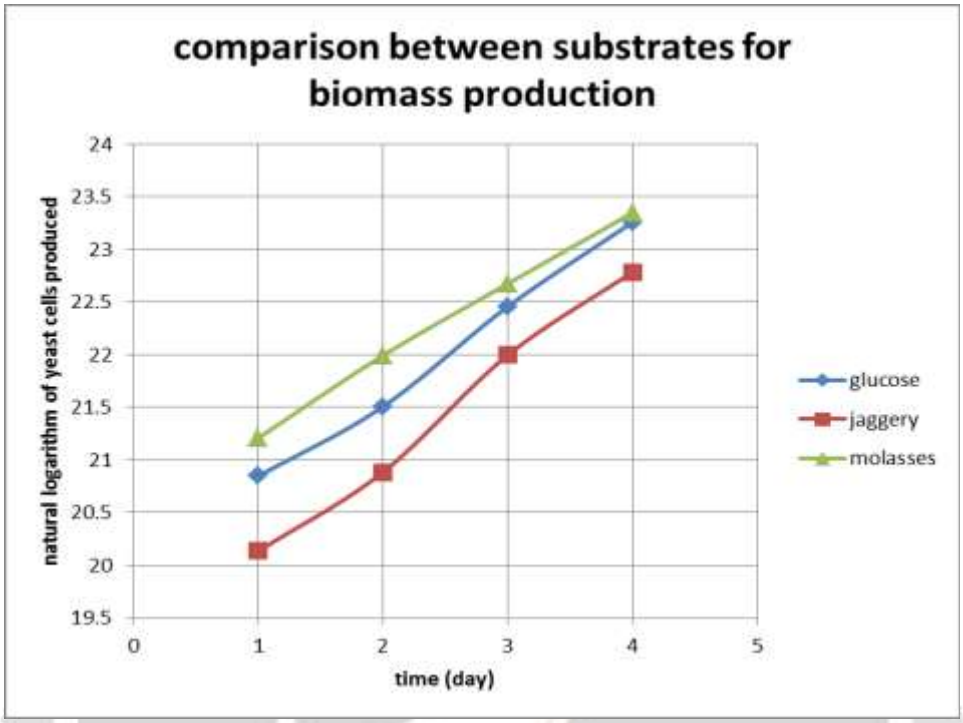

Chart-1: comparison between substrates for biomass production

Chart 1 shows the comparison of substrates for yeast cells production. The natural logarithm of the number of yeast cells is plotted against time. From the graph it is evident that the molasses produces the most amount of cells.

3.2 Comparison between substrates for maximum alcohol production (at the end of day 4)

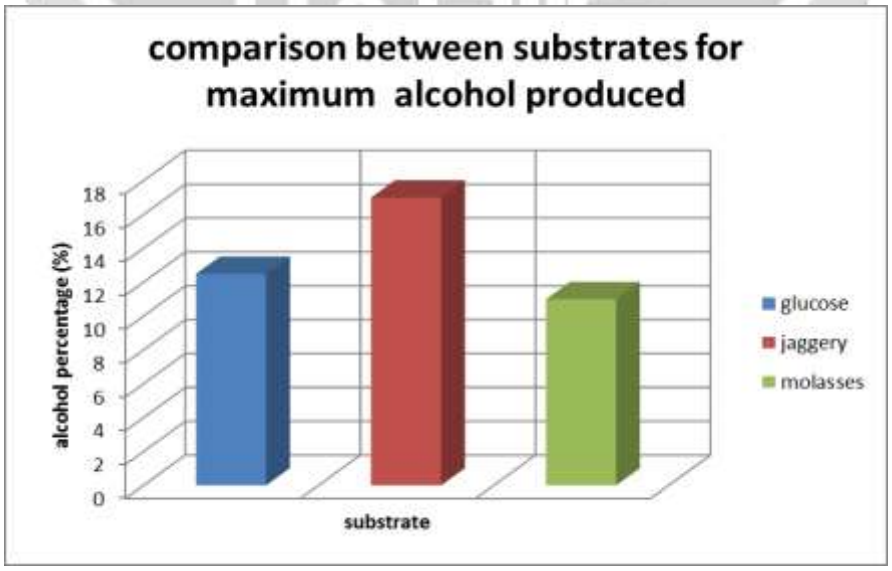

Chart-2: comparison between substrates for maximum alcohol produced

From chart 2, we can see that the substrate jaggery produces most amount of alcohol at the end of day 4.

3.3 Comparison between substrate for alcohol percentage

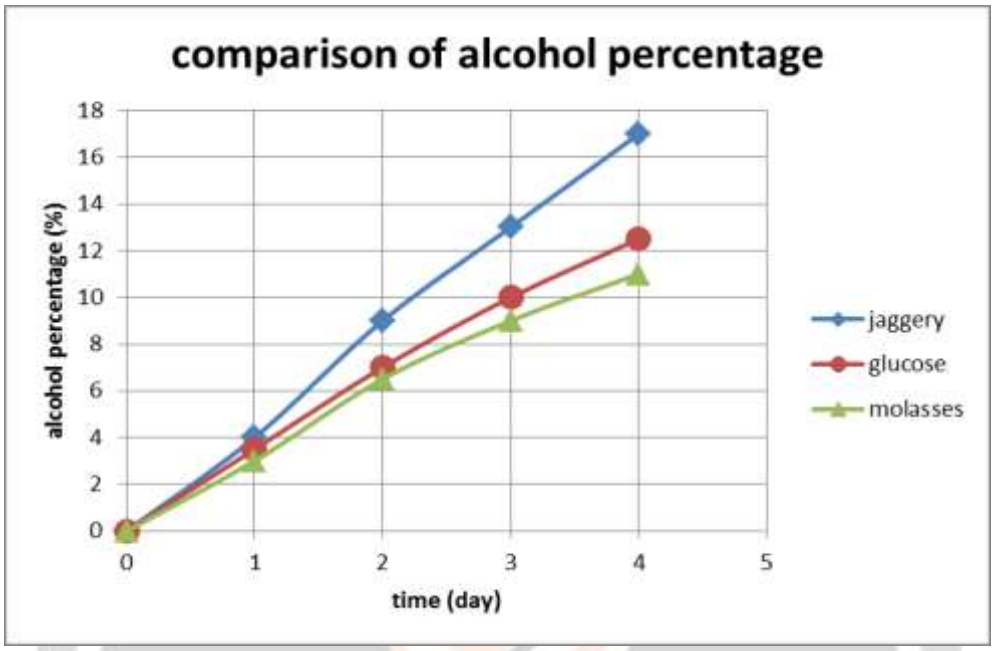

Chart-3: comparison of alcohol percentage for substrates

3.4 Cost comparison for substrates

Cost analysis for the substrates on the basis of cost for producing 1 ml of ethanol is done. In table 3 the price of the components based on their composition in 1 lit of production medium is shown. In table 4, the amount of alcohol produced by 1 litre production medium for the substrates as well as the number of cells produced is shown for each substrate respectively.

Table-3: Price (in rupees) per litre of production medium

	price (rs/lit)		
component	**glucose**	**jaggery**	**molasses**
sugar	254.745	11.5	9.775
peptone	278.74	278.74	278.74
yeast extract	110.54	88.432	88.432
(NH4)2SO4	19.53	9.765	9.765
MgSO4	55.97	55.97	55.97
KH2PO4	17.952	8.976	8.976
Total cost	737.477	453.383	451.658

Table-4: amount of alcohol and yeast cells produced per litre of production medium

substrate	maximum alcohol produced	ml of alcohol produced per litre of production media	total number of cells produced	total number of cells produced (x10^9)
glucose	12.5	125	12628800000	12.6288
jaggery	17	170	7870500000	7.8705
molasses	11	110	13810500000	13.8105

Table-5: Total cost (in rupees) per ml of alcohol and per 10^9 cells produced

substrate	glucose	jaggery	Molasses
price per ml of alcohol produced (Rs.)	5.89982	2.66696	4.105982
cost per 10^9 cells produced (Rs.)	58.5299	57.609	32.72884

The highlighted values in table 5 are the minimum for alcohol and cell production. The cost for producing alcohol is least if we use jaggery and if we need to produce cells then molasses is the right choice as substrate.

4. CONCLUSION

From the results we have found out that the yeast production is done the best and cheapest by molasses among the three substrates chosen. Jaggery is the most cost effective substrate of the three for alcohol production. Similar analysis and comparison can be done for other substrates. The cost comparison thus helps in choosing the best raw materials for fermentation process.

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[4.] www.sigmaaldrich.com < price catalogue for chemicals>