Production of Biofuel Ethanol in Sugar Industry from Molasses

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Abstract: Biofeul ethanol is common organic solvent and widely used in laboratory as well as in different industries. Now a days its most important use in the blending with petroleum products which overcomes the energy crisis and also, it is environment friendly, it is non-exhaustable or renewable source of energy, hence, widely used in the auto-mobile sectors as a biofuel. Demand of bioethanol increases day by day as a fuel supplement and chemical feedstocks in developing countries. The aim of this work is to study the bioproduction of ethanol with the help of yeast or Saccharomyces cerevisae from different types of molasses. It is cheap source of bioethanol and byproduct of sugar indusry. It contains 45% to 56% of sugars, mostly Sucrose, our main aim is to obtain maximum yield of ethanol by fermentation process using yeast species like AK-22. Different factors life temperature, pH, concentration of sugars, agitation rate, formation of foams etc., influence the production of ethanol and also efficiency and metabolism of yeast or Saccharomyces cerevisae.

Key Words: Saccharomyces cerevisiae (AK-22), Molasses, Fermentation, Hydrolysis, pH, Temperature, Formation of foams, Concentration of sugar, Agitation rate, Dissolved Oxygen Concentration etc.

INTRODUCTION

Lower alcohols are the most common organic solvent hence, used in different sector like pharmaceutical industry, chemical industry, pesticides formation of polymers and resin, as a lubricants and laboratory. Now a days all the most important use of ethanol is in petroleum industry as a biofuel. Its proper amount blend with petrol and diesel used in automobile sectors as a fuel. Its demand increases day by day because its renewable source and causes less pollution than that of petroleum products. Different carbohydrates changed into lower monosaccharide units after hydrolysis and enzymatic reactions. The main aim of this work is to production of biofuel ethanol from molasses in sugar industry with the help of Saccharomyces cerevisiae AK-22 species with maximum yields factor like pH, temperature, agitation rate, concentration of sugar is under controlled and suitable medium, which enhanced the production of bioethanol industries.

METHODOLOGY

Different types of substances instruments, chemicals glasswares, yeast species etc., are used in the fermentation process for the production of ethanol from molasses.

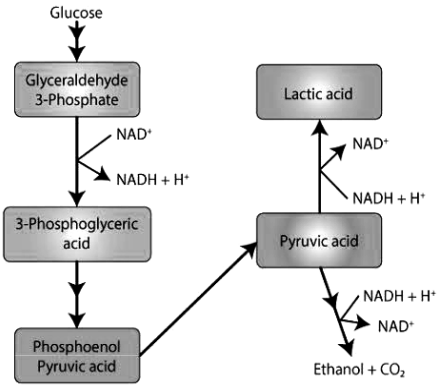
1. Molasses :

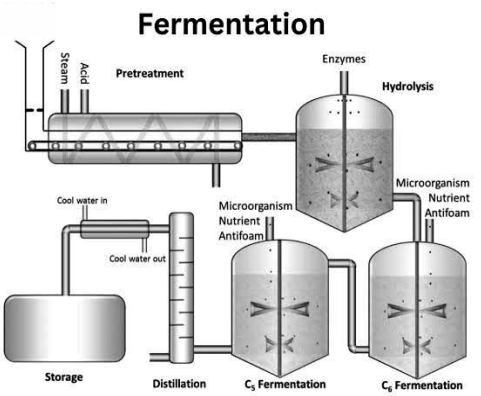
Different types of molasses are taken like Grade-A, Grade-B, and Grade-C etc. (15.5%-17% (W/V).

2. Malt extract (0.300%).
3. Saccharomyces cerevisiae or yeast extract (0.300%).
4. Double distilled D.M. water.
5. Optimum pH value 4.2–4.8.
6. Optimum temperature 25°C–37°C.
7. Nutrients, vitamins, minerals etc,. added during fermentation which influences production of ethanol.
8. Beaker, conical flask, pipette, burette, measuring flask, measuring cylinder etc. are used all are borosil standard.
9. Preparation of culture and production medium.
10. Saccharomyces cerevisiae AK-22 species, ferment sugars, after this, ethanol is produced, which is determined by Calorimetric determination, other residues left in solution.
11. Different chemicals like lead acetate, NaOH, HCl, Fehling A solution. Fehling B solution, methylene blue, glucose phenolphthalein, H_2SO_4, chromic acid etc, of best quality were used.
12. Instrument like weighing machine water thermostat incubator, oven heater, alcoholmeter etc, were used.

Different parameters like pH, temperature, agitation rate, concentration of sugars, selection of raw materials, incubation period of alcoholic fermentation etc, are optimized for maximum yields of biofuel ethanol. Chemical and physical mutagens also affects the production of ethanol.

Every fermentation medium used be divided into ten equal parts (10 mL each) which is diluted to 100 mL in separate flask, plugged with cotton and placed in autoclave for 15 minutes. After cooling 0.05 mL Saccharomyces cerevisiae AK-22 is inoculated. The flask would be the incubated at 32°C and after 32 h, 48 h, 50 h adn 52 h of incubate period. The produced ethanol during the course of fermentation is estimated calorimetrically.





RESULTS AND DISCUSSION

Molasses is a by product of sugar industry contains, 45% to 56% sugars, mainly sucrose.

Different types of Molasses:

1. Sugarcane Molasses : It is most important feedstock for the production of biofuel ethanol in sugar industries. Its production is nearly 11-22 million tons/year. Molasses are divided into grades.
Grade A : Its T.R.S. Percentage is obove 48% its brix is above 85 and its ash content is 12-13%.
Grade B : Its T.R.S. percentage is above 42% its brix is 83-88, whereas, its ash content is 13-15%.
Grade C : It is low grade molasses, its T.R.S. percentage is above 35%, its brix is 82-85, whereas its ash content is 16-18%.
The yields are 200-250 litres/ton of molasses.
2. Sugar Beet Molasses
3. Chitaa Molasses
4. High Test Molasses
It is a concentration sucrose solution and contains sugar percentae between 70%-80%.
5. Black Strap Molasses

Different types of feedstocks with percentage of sugar and its yields.

S.N.	Feedstocks	Percentage of Sugar	Yields (Litres/ton)
1.	Sugarcane juice	35–45	70–80
2.	Sugarcane molasses	48–49	230–270
3.	Beet Molasses	48–49	250–260
4.	Sugar beet juice	12–13	80–130
5.	Black strap molasses	50–51	250–255
6.	Mahua flowers	50–67	225–250
7.	Cashew apple	7–8	60–62

Some important starch containing grains/crops

S.N.	Feedstocks	Percentage of Starch	Yields (Kg/ton)
1.	Rice	80	430–450
2.	Corn	74	360–400
3.	Wheat	65	340–380
4.	Barley	64	250–300
5.	Sorghum	75	350–420
6.	Millets	70	400–450
7.	Potato	20	100–130

8.	Tapioca	65	400–430
9.	Sweet potato	25	150–180
10.	Rice bran cake	45	200–230

Starch containing feedstocks are converted to glucose after gelatinization, liquefaction and scarification process with the help of suitable enzymes.

Composition of Molasses :

1. Total solids → 80 – 88%
2. Reducing sugar → 12 – 18%
3. Sucrose → 30 – 40%
4. Fermentable sugar → 50– 55%
5. Non-Sugar Organic Compounds→20% – 25%
6. Ash → 7% – 10%
7. Moisture → 12% – 14%

Indian molasses is reported to good quality on the basis of :

(a) Fermentable to non-fermentable ratio.
(b) The concentration of impurities.
(c) Total organic volatile acidity and
(d) Sludge content.

Second generation feedstocks like lignin, cellulose etc., and third generation feedstocks like algal biomass required pre-treatment conditions.

Molasses (by product of sugar industry) is the main feedstock for the production of biofuel ethanol. It is 1st generation feedstock. All carbohydrates containing material can be converted to ethanol after fermentation process with the help of micro-ogranisms.

$$\text{Starch} + H_2O \xrightarrow{diastase} \text{glucose}$$

$$\text{Lactose} + H_2O \xrightarrow{Lactose} \text{glucose} + \text{galactose}$$

$$\text{Sucrose} + H_2O \xrightarrow{Invertase} \text{glucose} + \text{fructose}$$

$$\text{Maltose} + H_2O \xrightarrow{Malsase} \text{glucose} + \text{glucose}$$

Finally, ethanol is obtained from glucose by fermentation.

$$\text{Glucose} \xrightarrow{yeast} \text{ethanol} + CO_2\uparrow$$

Different steps are involved in the production of ethanol in sugar industries from molasses.

Step-1: Dilution of weighed molasses in proper amounts.

Step-2: Conversion of fermentation sugar to alcohol and carbon dioxide by fermentation process, with the help of micro-organisms like yeast or Saccharomyces Cerevisiae.

Step-3: Distillation process in this alcohols and spent was separated.

Step-4: Rectified spirit is obtained by distillation process.

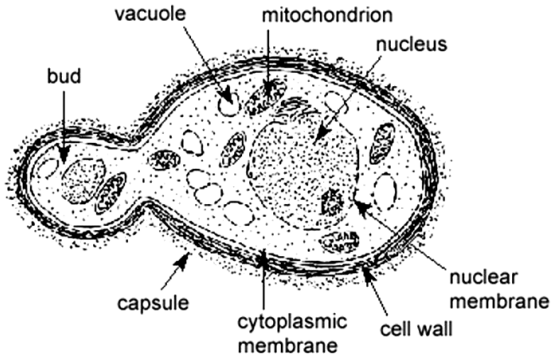
Step-5: After simering, extra neutral alcohol (E.N.A.) is obtained, whereas, after MSDH process, ethanol is obtained with purity 99.7%

Yeast or Saccharomyces Cerevisiae is the most common micro-organism to involve in fermentation process.

Its important features for favourable conditions during fermentation process is summarised below.

1. Osmotic pressure of the sugar solution is 25% (W/V).
2. Ethanol stress is 15% (v/V).
3. The optimum temperature is in between 32°C to 37°C.
4. The optimum pH value is less than 3.8.
5. The concentration of sulphite is less than 100 mg/L.
6. The lactic acid conentration is below 0.8% (W/V).
7. The concentration of acetic acid is below 0.05% (W/V).
8. The sodium ion concentration is below 500 mg/L.
9. Proper amounts of Urea, ammonium ions and minerals are also added.
10. Agitation rate is 150-200 rpm. According to Lie and Shen maximum biofuel ethanol yield (85.73%) at 200 rpm of agitation rate.
11. Dissolved oxygen concentration.
12. Formation of foam, it inhibits fermentation efficiency, hence foam is skimmed out in the fermented solution time to time.
13. Concentration of sugars and
14. efficiency and metabolism of yeast.

Fig.-1: Cellular structure of yeast



CONCLUSION

Ethanol is common solvent and used in different industries and in laboratory. Presently, its most important used in as a fuel, substitute for petroleum products, because renewable source and causes less pollution. The aim of this work is to study the production of ethanol with the help of yeast or Saccharomyces cerevisiae from molasses. It is cheap source of bioethanol and by product of sugar industry. It contains mostly sucrose. Factors like pH, temperature, agitation rate, sugar concentration, dissolved oxygen concentration etc. influences the production of biofuel ethanol. Our main aim is to obtain maximum yields of ethanol from molasses by the optimization and controlling the various factors and also the efficient yeast species like AK-22 was used. These conditions favours the maximum yields of ethanol. Chemical and physical mutagens also affects the ethanol production.

REFERENCES

[1] Advances in Agriculture Microbiology – D.S. Chahal and R.P. Overand.

[2] Colorimetric methods of analysis VIth Edition – D. Van Nostrant Camp, Inc. Brinceton, New York.

[3] F.W. Bai, W.A. Anderson and M.Moo-Young, "Ethanol fermentation technologies from sugar and starch feedstocks, Biotechnology Advances, vol. 26, no. 1, pp. 89-105, 2008

[4] Kapralek, F., J. Gen. Microbiol, 29, 4.3 (2018).

[5] L. Liang, Y- P. Zhang, L. Zhang, M-J Zhu, S-Z. Liang and Y-N Huang, "Study of sugarcane pieces as yeast supports for ethanol production from sugarcane juice and molasses." Journal of Industrial Microbiology and Biotechnology, vol. 35, no. 12, pp. 1605-1613, 2008

[6] Manual of Methods of General Bacteriology, American Society of Microbiology, Washington – Gerhardt. P.

[7] Outlines of Chemical Technology – East-West press Pvt. Ltd., New Delhi.

[8] P. Ghosh and T.K. Ghose, Bioethanol in India: Recent Past and Emerging Future, Springer, Berklin, Germany, 2003

[9] Rathor, N., Samdamni, Sinha, A.K., Kumar L. at al. – Indian J. Org. Chem. Vol. XXIII (2,3), pp.-191-195 (1990)

[10] Singh, S.P., Mandal, D.C., Singh, B., Rathor N., – J. Current Science (2008).

[11] Singh, S.P., Pandey Rikita, Brahmchari, A.K., Pratap, B. – Asian Journal Chem., 6, 753-755 (1994).

[12] Singh, S.P., Verma, A.K., Singh, B.K. and Kamal, K.P. – Asian Journal Chem. 9, 886 (1997).

[13] S. Brethauer and C.E. Wyman, "Review : Continuous hydrolysis and fermentation for cellulosic ethanol production", Bioresource Technology, vol. 101, no. 13, PP. 4862-4874, 2010

[14] Yeast Technology, Van Nontrant Reinhold, New York (1991) –by Reed G. and T.W. Nagodawithana.

[15] Xu, J.; Li, M.; Ni, T. Feedstock for bioethanol production from a technological paradigm perspective. Bio Resources 2015, 10, 6285-6304 [cross Ref].

[16] Renewable Fuels Association (RFA). Annual Fuel Ethanol Production. 2020. Available on line : https://ethanolrfa.org/statistics/annual-ethanol-production/(accesed on 22 April 2021).

[17] Ribeiro, B.E. Beyond common place biofuels : Social aspects of ethanol. Energy Policy 2013, 57, 355-362 [Cross Ref].

[18] Carriquiry, M.A.; Du, X.; Timilsina, G.R. Second generation biofuels : Economics and Policies. Energy Policy 2011, 39, 4222-4234. [Cross Ref].

[19] Ziolkowska, J.R. Biofuels technologies. In Biofuels for more Sustainable Future; Elsevier Inc.; Amsterdan, The Netherlands, 2020; PP. 1-19 [Cross Ref].

[20] Ramachandra, T.V.; Hebbale, D. Bioethanol from macroalgae : Prospects and challenges Renew. Sustain Energy Rev. 2020, 117,

109147 [Cross Ref].

[21] Prasad. S.; Singh. A.; Joshi. H.C. Ethanol as an alternative fuel from agricultural industrial and urban residues.

[22] Ingale, S.; Joshi, S.J.; Gupta, A. Production of bioethanol using agricultural waste; Banana Pseudo stem. Braz. J. Microbiol. 2014, 45, 885-892. [Cross Ref].

[23] Bisson, L.F.; Butzke, C.E. Diagnosis and rectification of stocks and sluggish fermentation. Am. J. Enol. Vitic. 2000, 51, 168-177.

[24] Thomas, K.C.; Ingledew, W.M. Production of 21% (V/v) ethanol by fermentation of very high gravity (VHG) Wheat mashes. J. Ind. Microbiol, 1992, 10, 61-68. [Cross Ref].

[25] Lam. F.H.; Ghaderi. A.; Fink G.R.; Stephanopoulos, G. Engineering alcohol tolerance in yeast. Science 2014, 346, 74-75, [Cross Ref].