Comparison of Industrial Scale Ethanol Production from a Palmyrah-Based Carbon Source by Commercial Yeast and a Mixed Culture from Palmyrah Toddy

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ABSTRACT

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Palmyrah (*Borassus flabellifer*) based products were used as an alternative carbon source for industrial scale ethanol production. The fermentation medium was enriched with spent wash obtained from a distillation column. The performance of a commercially available baker's yeast in the media was compared with a 'palmyrah toddy mixed culture' where the organisms were obtained from the sedimentation of palmyrah toddy. In a laboratory scale study, the ethanol produced from a palmyrah fruit pulp extract, diluted with distilled water, was 16.5 gL^{-1} (36 h) and 13.0 gL^{-1} (48 h) with 'palmyrah toddy mixed culture' and baker's yeast respectively. The 'palmyrah toddy mixed culture' performed better than the baker's yeast with palmyrah fruit pulp extract, diluted either with distilled water or spent wash. Among the different palmyrah based carbon sources, both cultures preferred molasses diluted with spent wash and both performed best in the medium containing the spent wash supplemented with sucrose. In a 5,000 L industrial scale fermentation of 20° Brix molasses supplemented with 10 gL^{-1} ammonium sulphate, 72 gL^{-1} and 65 gL^{-1} ethanol was produced by the 'palmyrah toddy mixed culture' (72 h) and the baker's yeast (90 h) respectively. As the performance of the 'palmyrah toddy mixed culture' was better than that of the baker's yeast, the former was selected for the industrial scale studies of molasses fermentation media diluted with spent wash. In these studies the temperature reached 42°C by 36 h and resultant cell death was observed. However ethanol production was higher and more rapid in the molasses diluted with spent wash, rather than in the molasses diluted with tap water and supplemented with $(NH_4)_2SO_4$. Cell recycle operation obviated the interruption in fermentation caused by temperature induced cell death and increased rates and efficiency of ethanol production were observed.

Key words: fermentation, molasses, palmyrah, 'palmyrah toddy mixed culture', yeast.

Abbreviations: PFP - palmyrah fruit pulp, PC - palmyrah toddy mixed culture, DPFP - depectinized palmyrah fruit pulp, BY - Baker's yeast.

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INTRODUCTION

Ethanol is produced on an industrial level mainly for the production of alcoholic beverages and in some parts of the world as a substitute for fuel[13]. In Sri Lanka, alcohol is produced for the manufacture of alcoholic beverages such as beer, arrack and brandy. The ethanol produced in the northern part of Sri Lanka, especially in the Jaffna peninsula, is from the naturally fermented palmyrah and coconut sap called 'palmyrah toddy' and 'coconut toddy' respectively. The inflorescence of palmyrah and coconut palm is seasoned and the sap (containing 100–160 gL^{-1} of total sugar) is collected in clay pots (approximately 3L capacity) where it is fermented to mixed alcohols such as ethanol, fusel oils (higher alcohols), acetaldehyde, vicinal diketones and esters[4] by air borne microorganisms. Usually the time given for the sap to ferment is about 10 to 18 h and the toddy is collected in the early morning and evening. When the toddy is collected, the sedimented cells are left out in the pots and are reutilised. The fermented sap, i.e. 'toddy', is taken to the distilleries for the manufacture of potable spirit. Spent wash is the effluent waste from the distillation column.

There are over 10 million palmyrah palms in Sri Lanka, spreading over 60,000 acres. The Jaffna peninsula has 7×10^6 palmyrah palms growing widely[9]. A palmyrah palm gives 200–300 fruits per season. About 125 million fruits are produced by all palmyrah palm in Sri Lanka. The average weight of a fruit is 2.25 kg, of this about 40% is pulp[7] and the total sugar content of the pulp is 100 gL^{-1}. As a growing interest emerges in renewable feed stocks for fermentation, the palmyrah based carbon sources are being considered. Previously attempts were made to mechanically extract palmyrah fruit pulp (PFP)[7] and to ferment the palmyrah fruit pulp on a large scale[1].

In areas where the fermentation technology is not refined, any available yeast is used for the fermentation of the pulp. This is likely to be a baker's yeast, and in most cases this gives reasonable results as these yeasts have good fermentative activity. However, with substrates such as palmyrah based carbon sources, they may not perform satisfactorily. Therefore this study was undertaken to compare the performance of baker's yeast (BY) with that of the organisms obtained from the sedimentation of 'palmyrah toddy'. In this paper the utilization of PFP and un-