Abstract

Chapter 1: Introduction

This chapter gives the general introduction on the cellulase production by solid state fermentation. It gives brief review of literature on development of solid state fermentation process. Solid state fermentation process is mainly used for the traditional food processing and the fungal enzymes production. Solid state fermentation is an old method being used for achieving new objectives with the advent of new approaches and development in biochemical engineering. This chapter describes the bibliographic details on cellulase, produced by various micro-organisms have been stated. The various types of designs in use and in developmental stages have also been discussed. The substrates play a major role in deciding the cost of the fermentation products and hence the agro-base various substrates are also discussed stating its importance. In addition, solid state fermenter types and pros and cons associated with the SSF process are deliberated. Finally the objectives of the research have been stated.

Chapter 2: Literature review of SSF design (packed bed)

This chapter discusses literature review of packed bed SSF design and highlights the merits and demerits of each design of packed bed solid state fermentation (PBSSF). The packed bed design of SSF is widely accepted as it has a simple design and cost effective design accumulating large volume of substrate in a cylindrical column although, large volume makes it critical to control the parameters of fermenter. Heat accumulation is a major technical problem with large capacity PBSSF; hence various technical problems like channeling, bed shrinkage in a column, formation of axial temperature gradients,
flooding concepts etc. having nuisance value in the fermentation process and hence deliberated in this chapter. In addition, various types of packed columns used for SSF along with bibliographic details on various products formed by PBSSF and its applications are discussed.

Chapter 3: SCREENING, OPTIMIZATION OF CELLULASE PRODUCING ORGANISM ON DIFFERENT SUBSTRATES

In the current work, cellulase production studies were carried out for which many cultures were isolated and screened for better cellulase production. Among the isolates, one better cellulase producer was identified and used further for experimentation. It was *Aspergillus oryzae* which was checked for its ability to utilize three different lignocellulosic residues by solid state fermentation (SSF) process. The C:N ratio and cellulase yield were recorded for all the three substrates available in the region like JS, WS and TS where after fermentation, the protein enrichment was also observed. JS exhibited the highest yield of 192 IU/g for cellulase while WS showed 186 IU/g followed by 109 IU/g for TS. Parameters like pH and temperature were optimized with cellulase production and found that cellulase production was high at 6.0 pH and 30°C temperature. The chemical compositions of agro-waste and average particle size effect on cellulase yield were also studied.

Chapter 4: STUDIES ON PACKED BED SOLID STATE FERMENTER (PBSSF)

The packed bed solid state fermenter (PBSSF) was designated and constructed in the present study to understand the temperature gradient formed in column. The experiments
were carried out in packed bed fermenter with jowar straw (JS) as a substrate. While the culture used for fermentation was an isolate *Aspergillus oryzae*. Temperature gradients formed inside the column were determined using temperature sensors at different axial positions. Inside the column, temperature rise was observed maximum to a value of $11^\circ$C difference above the optimum temperature. It was found that the organisms grew slowly from 0 to 30 h of lag phase, further it grew rapidly from 30 to 50 h. In this duration heat generation was more. The carbohydrate based substrate jowar straw upon fermentation showed three-fold increase in protein content than that of initial which can be used as high value nutritional feed to animals. Effects of inert packing material on temperature variation were observed approximately from 0.2 - 2$^\circ$C along the axial length of column. Lignin content (LC) relations with water holding capacity (WHC) and calorific value (CV) of substrates (JS, WS and TS) were also studied.

**CHAPTER 5: MODELING AND SIMULATION OF TEMPERATURE GRADIENTS IN PACKED BED SOLID STATE FERMENTER**

Modeling of solid state fermenter plays a vital role in understanding the bio process, design and development. Packed bed solid state fermenter (PBSSF) showed certain specific application over another types of SSF. Overall efficiency of this reactor majorly depends on the temperature gradients formed inside the column and hence in this research work, kinetic and lumped heat transport model were used for simulating the microbial growth in the PBSSF. *Aspergillus oryzae* was grown on JS and then experimental findings were validated by checking its fitness with the lumped model which was acceptable.