Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Der Pharmacia Lettre, 2013, 5 (1):100-106
(http://scholarsresearchlibrary.com/archive.html)

Der Pharmacia Lettre
Scholars Research Library
ISSN 0975-5071
USA CODEN: DPLEB4

Studies on development of a computer software controller for monitoring of fermentation process with special reference to pectinase producing *actinomycetes*

Suneetha Vuppu and Bishwambhar Mishra

School of Bio Sciences and Technology, VIT University, Vellore-632 014, Tamil Nadu, INDIA

ABSTRACT

Fermentation processes are dynamic, i.e., nonlinear and non-stationary in nature, thus leading to many difficulties in controlling the process up to a given set point. In addition, lack of cheap and efficient controllers makes certain variables out of control by mere on-line estimation. Measuring the state variables is difficult, especially on-line, and its control is even more difficult. These difficulties make the fermentational processes an excellent field for applications of advanced computer software for controlling any variable. These computer controlled software makes the general fermentation economically more efficient by reducing man-power, time and last but not the least, by increasing the efficiency. This paper gives a general outline on how such an important software controller is developed and calibrated with the fermenter for ideal operations with future prospects in pectinase production from Actinomycetes. We are highlighting this, because due to the recent inventions in computer programming, the interface which is used by the controllers these days are getting old and problematic leading to a vast field in which the research could be done and a new simpler and cheaper interface could be developed by using new age computer programming softwares. Thus Development of a Computer Software Controller for Monitoring of Fermentation Process will be discussed and presented by multimedia.

Key words: Fermentation, Pectinase, *Actinomycetes*, On-line control, Computer programming

---

INTRODUCTION

Microbial fermentation for pectinase production is a dynamic process now a days it plays a pivotal role in the modern world. To carry out measurements during fermentation for data analysis and control of the process, Special sensors or sophisticated probes, which differs somewhat from those in the chemical industry, have been developed for bioreactors.All sensors located in the sterile media must be sterilizable and some sensors must be specifically adapted to biochemical needs. The physical and chemical parameters can be either measured directly at many pilot plant or production fermenters or can be measures off-line in the laboratory [1,2,3].

Control systems are concerned with improving the reliability and reproducibility of the overall process ie production of pectinase from *Actinomycetes*. These control systems rely on a combination of on-line and off-line measurements using automatic or manual sampling without compromising the process or increasing the risk of contamination. The use of specific probes, however, remains very limited mainly because of their instability following sterilization on the one hand and their susceptibility to fouling on the other [4,5].

The high cost associated with many fermentation processes makes optimization of bioreactor performance through command control systems very desirable. Since the majority of fermentation process are either batch or fed-batch, it is important that we minimize the 'turn-around' time between different cycles to maximize output and, in turn, productivity. Control of fermentation is recognized as a vital component in the operation and successful production of many industries [6,7,8]. The recent upsurge in the developments of command control systems for the monitoring, automation and control of fermentation processes is largely due to the developments of a new generation of computers that are low cost yet very powerful. On-line pectinase estimation denotes that estimation of the processes involved in the fermentational process during the fermentation and Off-line pectinase estimation denotes that estimation of the processes involved in the fermentational process when the fermentation is not taking place. Complicated dynamics, nonlinearity and non-stationarity make controlling them a very delicate task. The main control goal is to get a pure product with a high concentration, which commonly is achieved by regulating temperature or pH at certain levels [9,10].

Different types of Reactors used for the production Pectinase

Table 1: Various types of fermenters used in the bioprocess technology

Types of Reactor	Brief Descriptions	References
Packed bed Reactor	Very simple, low cost, no control system. Flask stopped with cotton wool or gauze layers	[9, 30]
Fluidized bed Reactor	Column reactor with a perforated base. Air is blown and very effective removal of metabolic heat.	[13]
Drum Reactor	Made up of inclined cylindrical drum which is operated by gentle mixing of solid substrate in the fermenter	[12, 13]
Disk Fermenter	Excellent homogeneistaion of the medium and good heat transfer	[30]
Semi automated Reactor	Packed bed reactor with periodic agitation, sophisticated control of temperature (**First developed in University of Santiago, Chile**)	[10]
Erlenmeyer flask Fermenter	Very simple, low cost, allows numerous runs without regulation, passive aeration	[5]
Tray reactor	Good aeration, no heat build up and also no stirring	[8, 6]

Computer Controlled Fermentation with its Architecture

In general process of the fermentation method that is controlled by system design to point however the system are going to be operated, however information flow operated in and round the system and the way that information may be processed, understood, captured, keep and interrogated with its demand. The system is usually associate degree info changed system. The control system is generally an information exchanged system [11,12, 13].

The information regarding the fermentation method is monitored and detected by differing types of sensors and is transmitted to its amplification units that forwards this from electronic equipment to the controller. The controller receives data and additionally compares this new information to the pre-existing information regarding however the fermentation ought to be occurring in a very correct ways in that so once generating new information within the variety of mathematical algorithmic output which transmits the knowledge back to the fermenter, to an effect unit that then, translating this signal into an effect action [14,15, 16].

The computer file area unit assembled within the input-output systems whose main functions is to convert a mix of signals to a kind of electrical signal for to search out and assemble the informations. Subsequently these styles of signals area unit passed into a Programmable Logic Controller (PLC) [17,30]. In PLC various styles of management ways area unit programmed and. Within the PLC the computer file area unit fed into PID algorithms and different management functions, in nursing output is fed back to the fermenter via Inpur-Output cards.

The PLC is additionally connected with data highway which can be connected with the opposite fermenter systems. In most of the cases the information road consists of a Supervisory And Data Acquisition System (SCADA) [18,19,33]. This SCADA collects all the information and store it for later retrieval and interrogation of data. The SCADA isn't a information and usually it cannot offer correct answers to information kind queries. Recently the utilization of advanced graphics will facilitate to gift the operator with differing kinds of comprehensive and elaborate data on plant standing [20, 32].

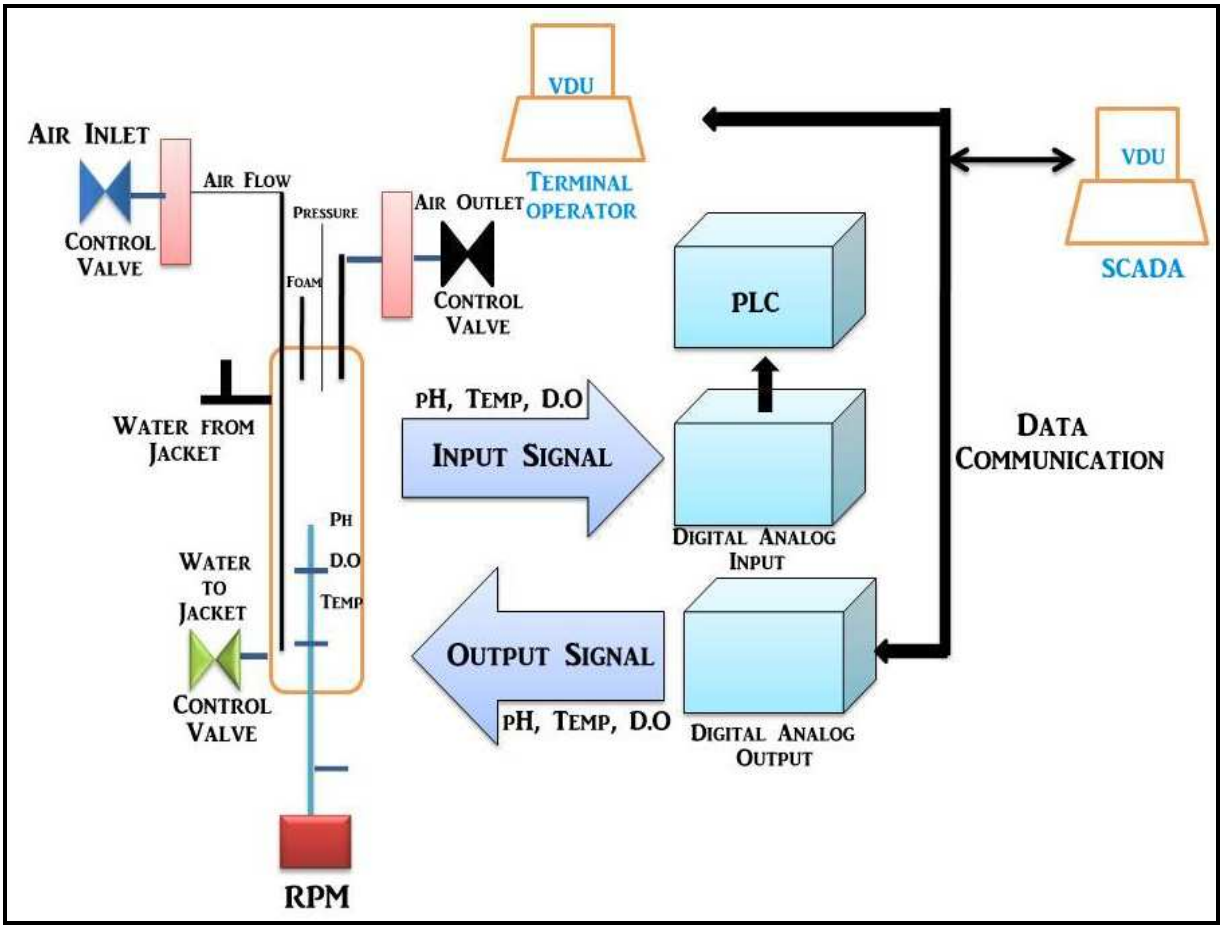

Figure 1: Control system for fermentation process

Various temperature sensing techniques and their Comparison

Table 2: Comparison of different temperature sensors [18, 19, 29]

Sensors Types	Thermistance	Metallic Probe (Pt 100)	Thermocouple (Metallic)
Temperature Range	-100 to 450°C	-260 to 1100°C	-270 to 400°C
Drawbacks	Lesser long term stability vs metallic probes. interchangeability of the probe	Higher price and higher response time	Measured temperature depends on the temperature of the cold junction
Advantages	High sensitivity. Short response time. Important signal. Versatile shape of the probe	Depends upon the Sensitive element. Simpler and more precise	Good fidelity. Satisfactory interchangeability

Fermentation Unit Operations

In chemical engineering and connected fields, a unit operation may be a basic step . Unit operations involve bringing a phase transition like separation, crystallization, evaporation, filtration etc. as an example, in pectinase production process, homogenisation, sterilization, and packaging are every unit operations that area unit connected to make the process. A method might have several unit operations to get the specified product [21,21].

Table 3: Various types of Unit Operation involving in the Fermentation Process [22,23,24]

S.l no	Unit operations	Description
1	Blank Sterilization	Employed as a pre-batching cleansing sequence when all steam and drain valves are opened.
2	Medium Batching	Fermenter is usually in a safe state for opening and preparation. During batching probe calibration and insertion into vessel must be complete before water is added to the vessel
3	Medium Sterilization	Sterilization sequence partly dictated by the fermenter vessel configuration and geometry, steam sterilization of the medium can be achieved by direct steam injection
5	Fermenter Inoculation	To introduce inoculation into the sterilized fermenter requires opening the vessel a controlled manner and introducing inoculation using strict aseptic techniques throughout
6	Incubation	The principal function of the incubation sequence is to start the clock counting the hour elapsed since inoculation during incubation the full functionality of the control system may be used to program the correct fermentation "trajectory" for the run.
7	Harvest	This could entail pre chilling or suitable ph adjustment of the broth to permit easier product recovery operations harvest could also include "killing" the vessels, i.e. sterilizing the vessel interior prior to safe opening and cleaning.
8	Cleaning	A number of options may be available here including full sterilization or heating in the presence of caustic detergents to fully automated clean in place (CIP) system with complex valve operations of their own.

Sequence Logic for production

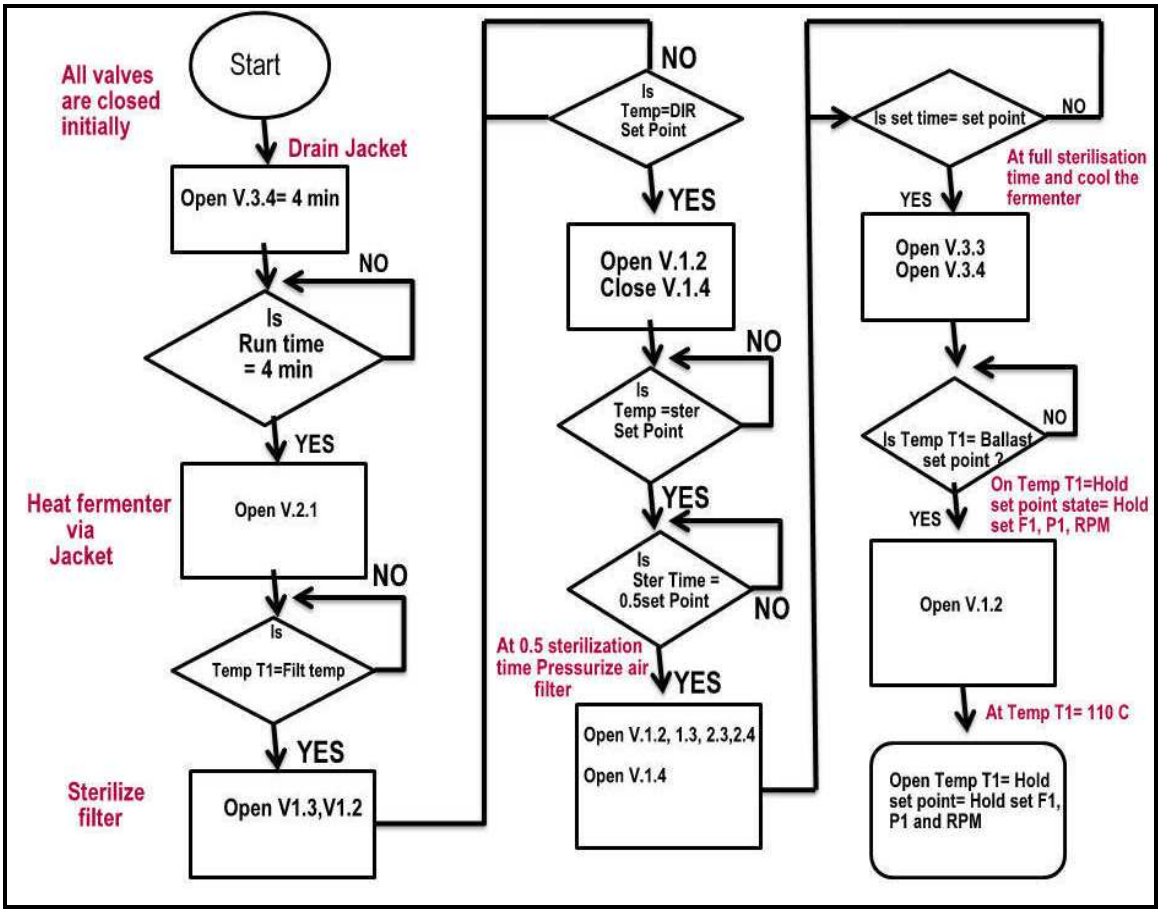

Figure 2: Sequence logic operation for the fermentation process

Fermentative production of pectinase from *Actinomycetes* needs management of multiple valves on an automatic fermenter needs the program to manage the gap and shutting of the valves such the state operations square measure effectively and safely completed. each of the vessel states indicated antecedently and probably several others ought to be programmed taking best human operator follow and engineering constraints under consideration [28,34,35].

Process a sequence follow a pattern of operating that ensures ambiguities square measure reduced and objectives square measure clearly expressed [27]. Taking one in every of the states because the sterilization of the bioreactor or fermenter and medium, the system developer should begin with an entire description of the fermenter and therefore the valves related to sterilization. an entire description can return from the correct drawing of the plant; these drawings square measure usually spoken as piping and instrumentation drawings (P&ID). The drawing can establish the units of management to be outlined within the program. trendy operative systems can tend to operate with structured code and it's attainable to think about individual blocks of code dominant individual units of management [36,37,38] .

This can be illustrates with reference to fig shown below, a typical fermenter configuration (a national P&ID) is shown for sterilization, only those valves are shown that are relevant to this highly simplified representation.

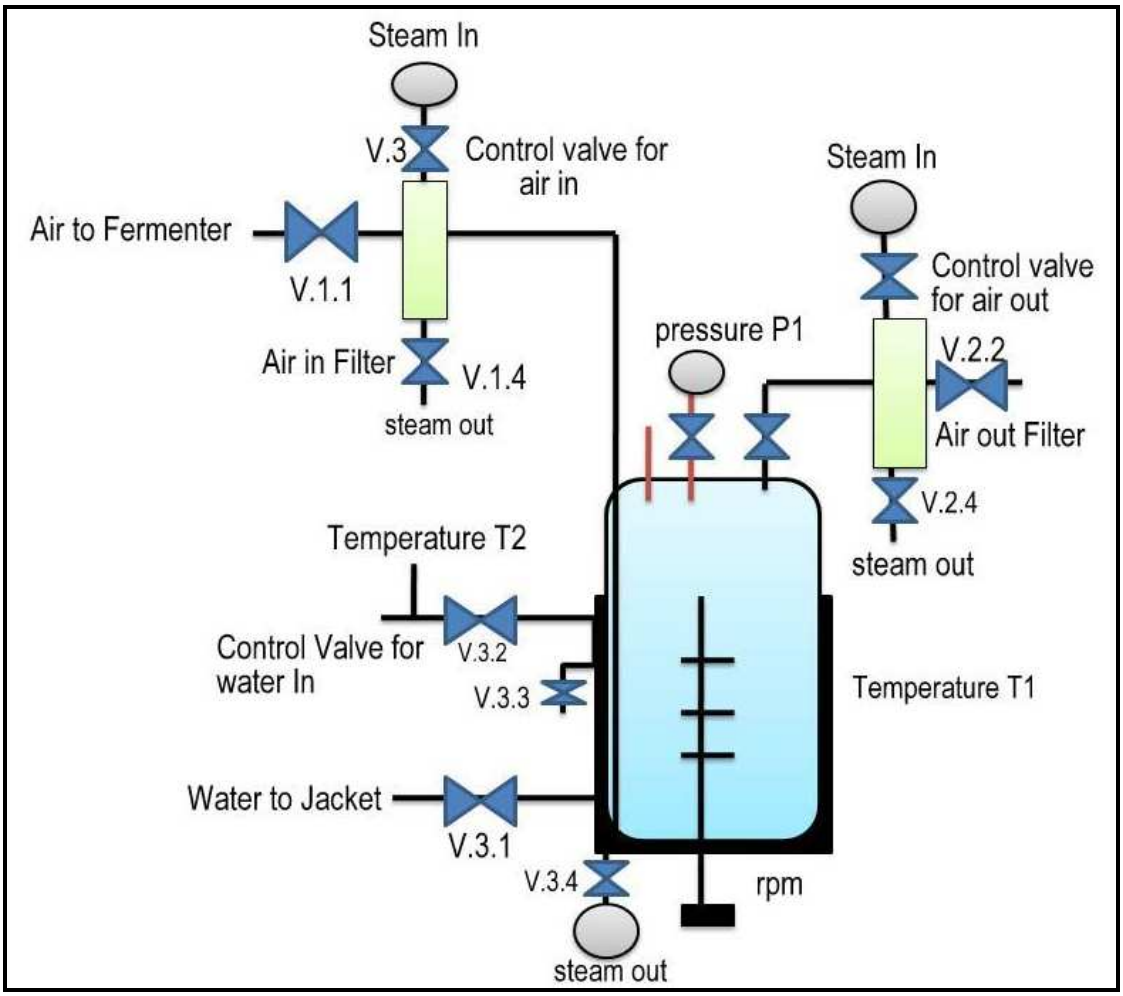

Figure 3: Sequence logic operation for the maintenance of aseptic condition [32]

Sequence Logic for Sterilization Operation

Here in this paper, we are focusing on development of sequence logic, flowchart and a simple executable program for controlling sterilization operation in a fermenter. The same logic and program is being used in all the controllers for sterilization of the fermenter and medium. The sequence logic is given below [25,26].

SEQUENCE LOGIC for sterilization or maintaining aseptic operations

1. START: here all valves are closed
2. Drain jacket
3. Heat-up phase
4. Direct-steam injection

5. Air filter sterilization
6. Sterilization temperature
7. Air filter pressurization
8. Crash cool
9. Ballast air
10. Broth hold

CONCLUSION

The sequence logic and flowchart shown here can be very efficiently used for the development of a simple user interface, fully automated computer controller for fermentation processes. Here in this paper, we are focusing on sterilization process which can be controlled easily and efficiently using such controllers. The computer controlled sterilization is very efficient and with the rapid boon in the computer industries these days, it is a very cheap process as compared to the manual control. A simple user interface controller will prove very beneficial for fermenters used by small infrastructure companies. The use of such controllers will enable these companies to compete with others.

Acknowledgement
All the authors appreciatively acknowledge the VIT University, Vellore and our honourable chancellor Dr. G. Viswanathan for providing the good laboratory facilities and infrastructure to carry out this research work. In addition we want to thank DST, India for the financial support.

REFERENCES

[1] A. Johnson, *Automatica* , **1987,** 23, 691–705.
[2] B. Dahhou, G. Roux, G. Chamilothoris, *J Appl Math Model*, **1992**, 16, 545–552.
[3] B.Mishra, V. Suneetha *Asi J Microbiol Biotechnol Env Sci*, **2012**, 14 , 369-374.
[4] P. Christen, R. Auria, C. Vega, E. Villegas, S. Revah *Biotechnol Adv* , **1993**, 11, 549-557.
[5] F. Renard, A.V. Wouwer, *J Comp Chem Engg* , 2008, 32, 1238–1248.
[6] I.O. Fasidi, O.S. Isikhuemhen, F. Zadrazil, *J Sci Ind Res*, **1996**, 55, 450-456.
[7] M. Fernandez, JR Pe´rez-Correa, I Solar, E. Agosin *Bioproc Engg*, **1996**, 16,1-4.
[8] H. Honda, T. Kobayashi, *J Biosci Bioengg* , **2000**, 89**,** 401–408.
[9] C.W. Hesseltine. *Proc Biochem*, **1977**,12, 29-32.
[10] B.K. Lonsane, N.P. Ghildyal, S. Ghildyal, S.V. Ramakrishna. *Enz Microbial Technol* **1985**,7,258-265.
[11] K. Hong, R.D. Tanner, P.S. Crooke, G.W. Malaney, *Appl Biochem Biotechnol*, **1988**,18,3-17.
[12] J. Horiuchi, *J Biosci Bioengg*, **2002**, 94, 574–578.
[13] J. Liang, Y.Q. Chen, *J Sys Cont Engg* , **2003**, I5, 427–432.
[14] J.A.D. Rodrigues, R.M. Filho, *J Chem Engg Sci*, **1999**, 54, 2745–2751.
[15] J.S. Alford, Journal of *Comp Chem Engg*, **2006**, 30, 1464–1475.
[16] L.J. Janik, R.H. Merry, I.O. Skjemstad *Aus J Exp Agri* ,**1998**, 38, 681-696.
[17] K. Oishi, M. Tominaga, A. Kawato, S. Imayasu, S. Nanba, *J Ferment Bioengg*, **1997**, 72,115–121.
[18] K. Shimizu, *Biochem Engg Biotechnol*, **1993**,50,65–84.
[19] K.B. Konstantinov, T. Yoshida, IEEE Transactions on Systems, Man, and Cybernetics ,**1991**, 21, 908–914.
[20] K.B. Konstantinov, T. Yoshida, *J Ferment Bioengg*, **1990**, 70 ,48–57.
[21] K.J. Astrom, *Automatica*, **1983**, 19 , 471–486.
[22] M. Hosobuchi, F. Fukui, H. Matsukawa, T. Suzuki, H. Yoshikawa, *J Ferm Technol*, **1993**, 76, 482–486.
[23] R. Aguilar, J. Gonzalz, M.A. Barron, R. Martinez-Guerra, R. Maya-Yescas, *Process Biochem* , **2000,** 36 , 1007–1013.
[24] R. Schneider, N.A. Jalel, A. Munack, J.R. Leigh, Proceedings of the Conference on Control Engineering ,**1994**, 36, 249–254.
[25] R.S. Parker, in: Proceedings of the American Control Conference, Anchorage, AK, USA, **2002**.
[26] Rai S, Mehrotra S, Dhingra D, Prasad M, Suneetha V. *Int J Pharma Sci Rev Res* **2012**, 17 ,40-43.
[27] M Raimbault, D. Alazard Eur J *Appl Microbiol Biotechnol* , **1980**, 9,199-209.
[28] M Raimbault, S Roussos, D.D. Proce production de spores de champignons filamenteux. French Patent #85 08555, 1985.
[29] S Ram Kishore, V. Suneetha Screening, *Asi J Microbiol Biotechnol Env Sci* , **2011**, 13 ,1-4.
[30] S. Ramaswamy, T.J. Cutright, H.K. Qammar, *J Process Biochem* , **2005**, 40,2763–2770.
[31] S. Sugimoto, M. Yabuta, N. Kato, T. Seki, T. Yoshida, H. Taguchi, *J Biotechnol* , **1987**, 40,237–253.
[32] S. Sanjay, K. Amod, V Suneetha, M. Bishwambhar, R. Gopinath, Y Sharad, M. Bhaskar *Int J Drug Dev Res* , **2012**, 4 ,304-310.

[33] V Suneetha, M Bishwambhar, R Gopinath, S R Shrestha, G K.B. Kartik , C Pravesh, C Apoorvi, R. Kalyani *Asi J Microbiol Biotechnol Env Sci* **2012**,14 , 405-412.
[34] V Suneetha, V. Raj *Int J Drug Dev Res*, **2012**, 4 ,1-6.
[35] V Suneetha, Ritika S, Abhishek G, Rahul G. *Res J Phamaceutical , Biol Chem Sci*, **2012**, 3 ,40-48.
[36] Suneetha V, Sindhuja K.V., Sanjeev K. *Asi J Microbiol Biotechnol Env Sci* , **2010**, 12 , 149-155.