**PROJEK SARJANA MUDA**
**SKB5814**

# EFFECT OF NORMALIZATION AND TRAINING ALGORITHM ON RADIAL BASIS FUNCTION NETWORK PERFORMANCE

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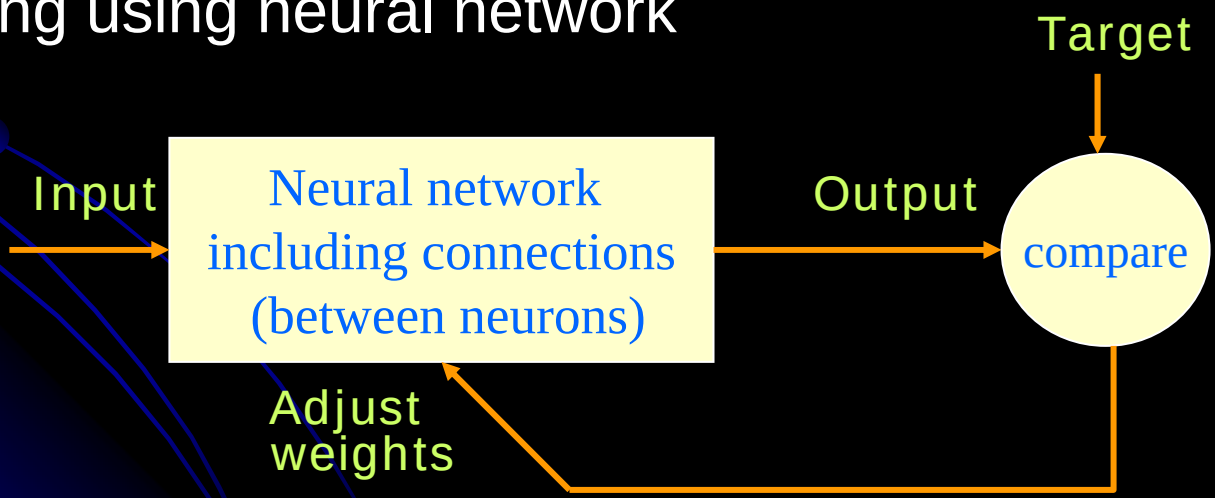
# Presentation outlines

- Introduction
  - Background
  - Scopes and objectives
- Research methodology
- Result and discussion
- Conclusion
- References

# What is neural network?

- Neural network is a computing system consists of a number of simple, highly interconnected nodes (processing elements) that process information.
- A concept that try to mimic how human brain functions

Training using neural network



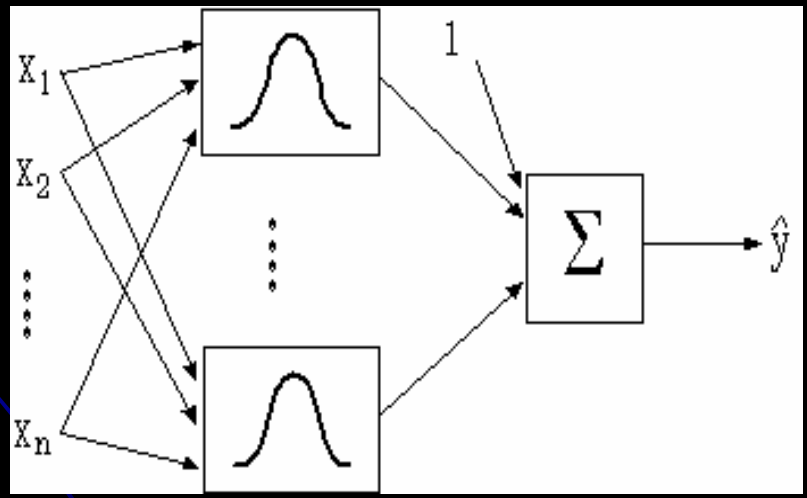
# Neural network models

- Consists of
  i. Multi-Layer Perceptron (MLP)
  ii. Recurrent Neural networks
  iii. Cascade Correlation
  iv. Radial Basis Function

- Neural networks such as Radial Basis Function (RBF) networks use in on-line process control because they require less computational time

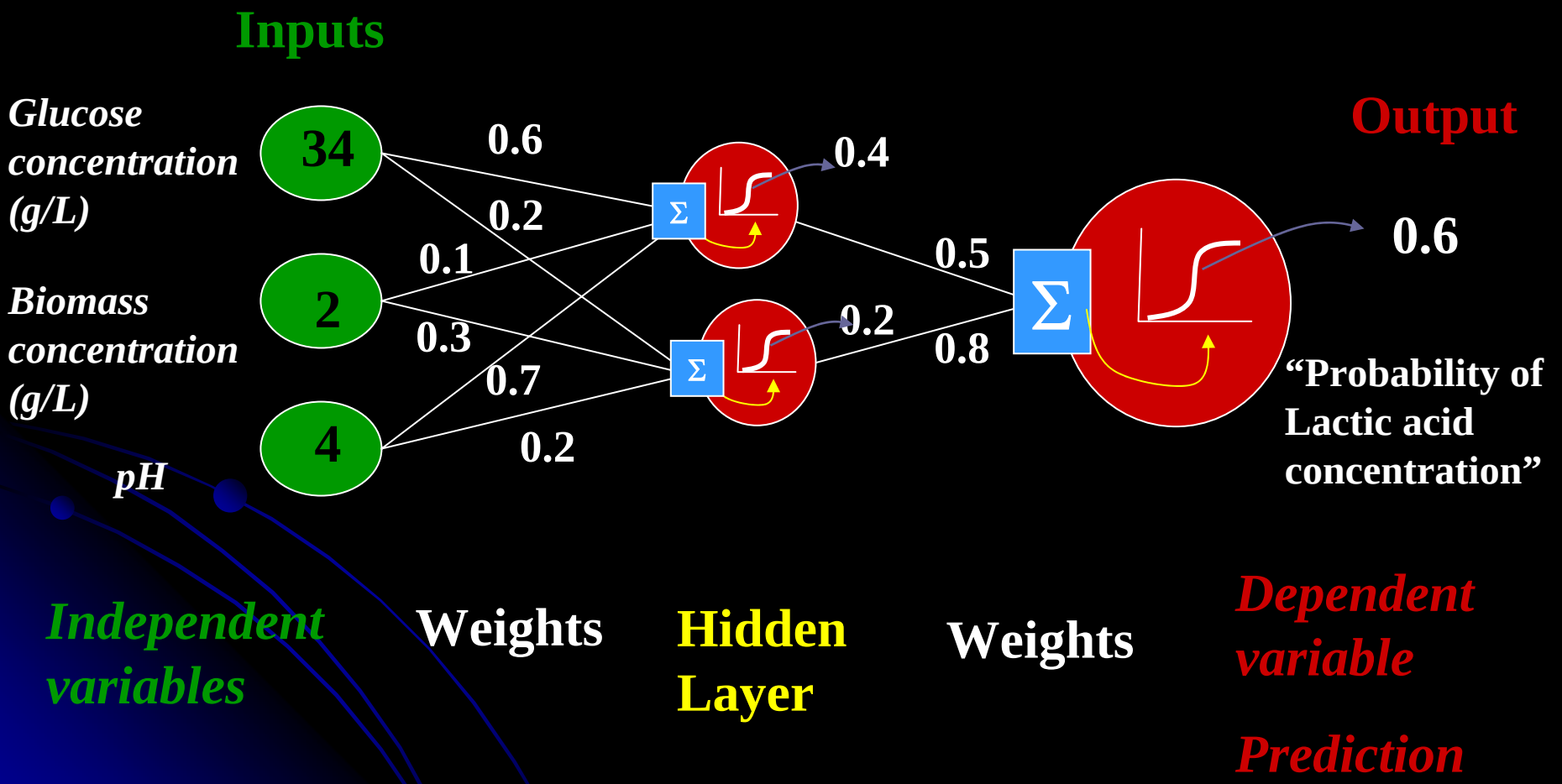
# Radial Basis Function

The RBF network is a three-layer network that uses a linear transfer function for the output units and a nonlinear transfer function for the hidden units.




Input layer Hidden layer Output layer

# Neural Network Model

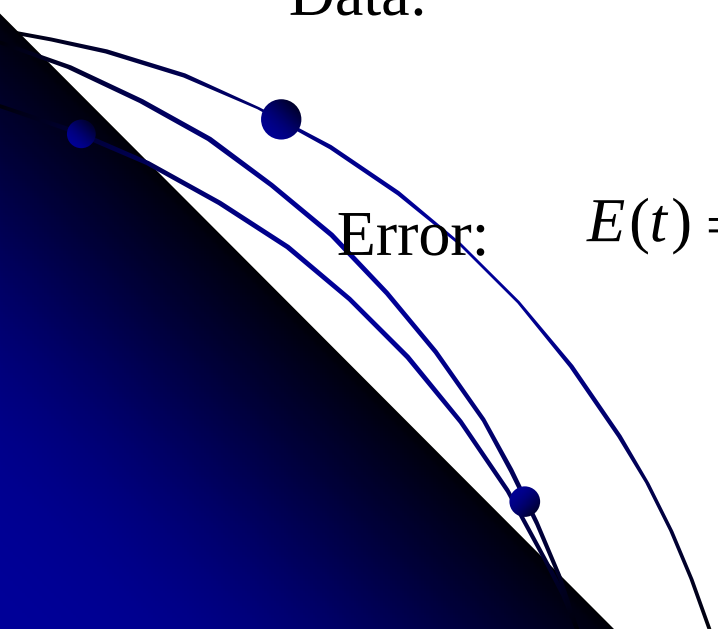


# Equation involved in RBF neural networks

RBF neural network: $$y_{out} = F(x, W) = \sum_{k=1}^{M} w_k^2 \cdot e^{-\frac{\|x - w^{1,k}\|^2}{2(a_k)^2}}$$

Data: $$(x^1, y_1), (x^2, y_2), \ldots, (x^N, y_N)$$

Error: $$E(t) = (y(t)_{out} - y_t)^2 = (\sum_{k=1}^{M} w_k^2(t) \cdot e^{-\frac{\|x^t - w^{1,k}\|^2}{2(a_k)^2}} - y_t)^2$$



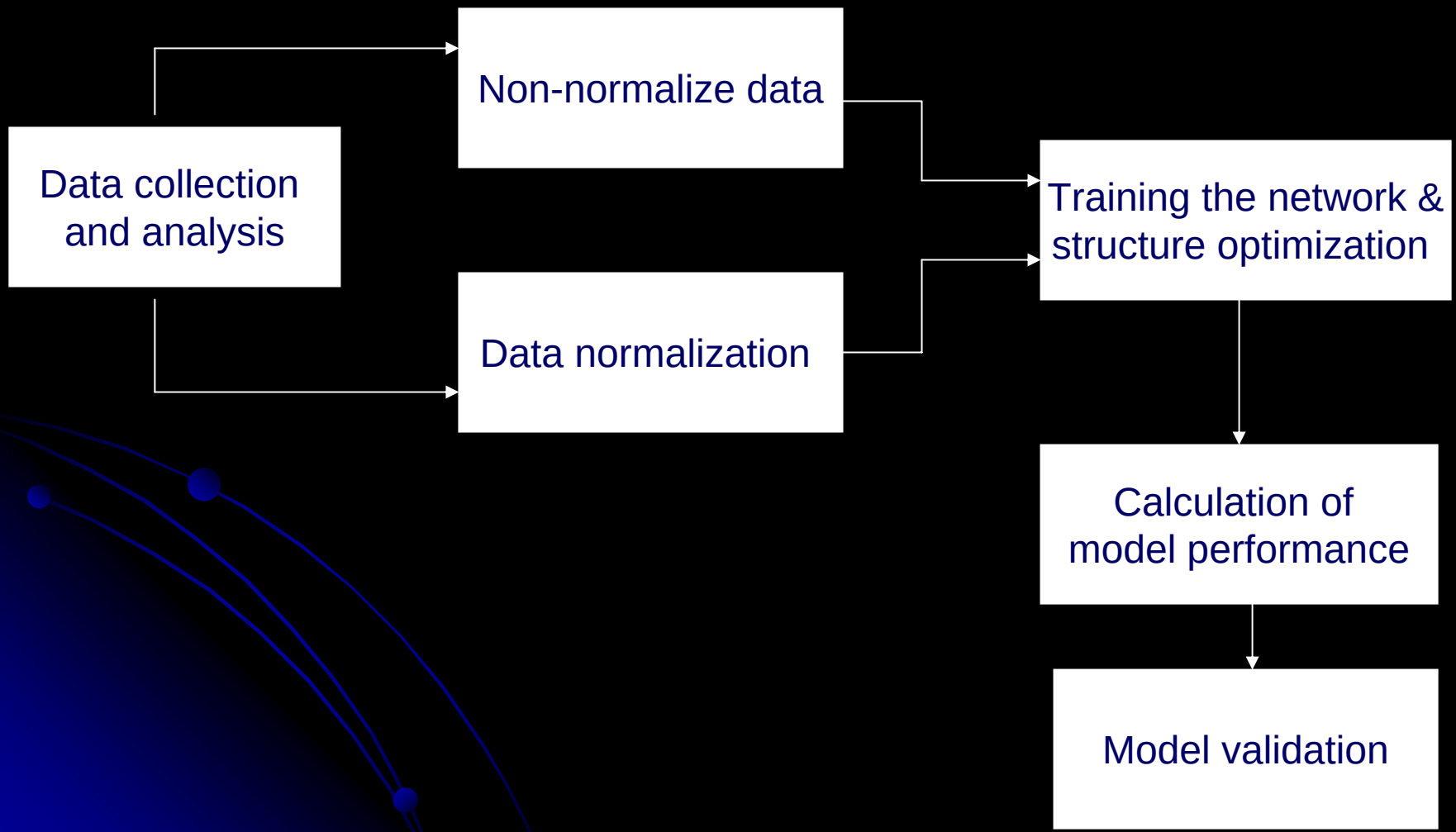
# Objectives

- To recognize the effect of normalization of data and training algorithm on Radial Basis Function (RBF) performance
- Use RBF to predict:
  - Relationship between lactic acid production and substrate concentration
  - Relationship between lactic acid production and cell concentration
  - Relationship between substrate concentration and cell concentration
- To develop software sensor for lactic acid production using RBF approaches

# Scopes

- Limited to the modeling for lactic acid production
- RBF model will be utilized in order to investigate the effect of normalization of data and training algorithm.
- Sets of experimental data for lactic acid production

# Research Methodology



# Effect of normalization

- Normalization is a process of scaling the numbers of dataset to improve the accuracy of numeric computation.
- $X_n = X_i/X_{max}$

  Where: $X_n$ = Normalized data

  $X_i$ = Data value

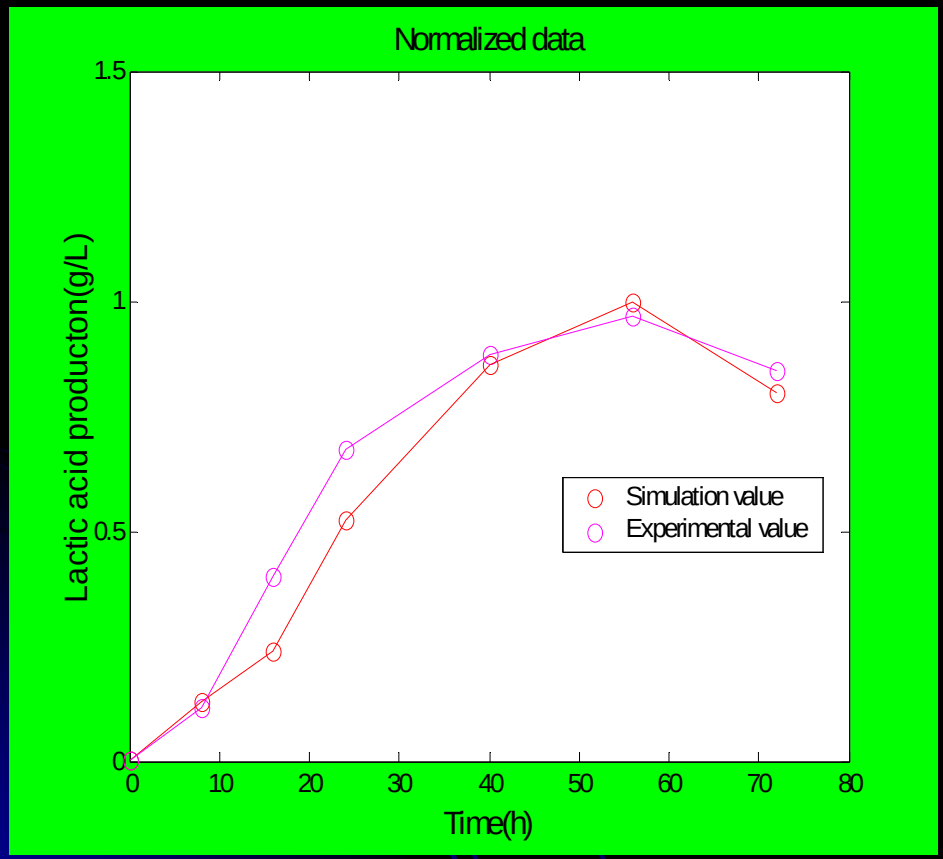
  $X_{max}$ = Maximum data value

| Time (hr) | Lactic acid production (g/L) at pH 4.5 | |
|---|---|---|
| | Non-normalized data | Normalized data |
| 0 | 0.02 | 0.00198 |
| 8 | 2.47 | 0.24503 |
| 16 | 4.73 | 0.46924 |
| 24 | 10.08 | 1.00000 |

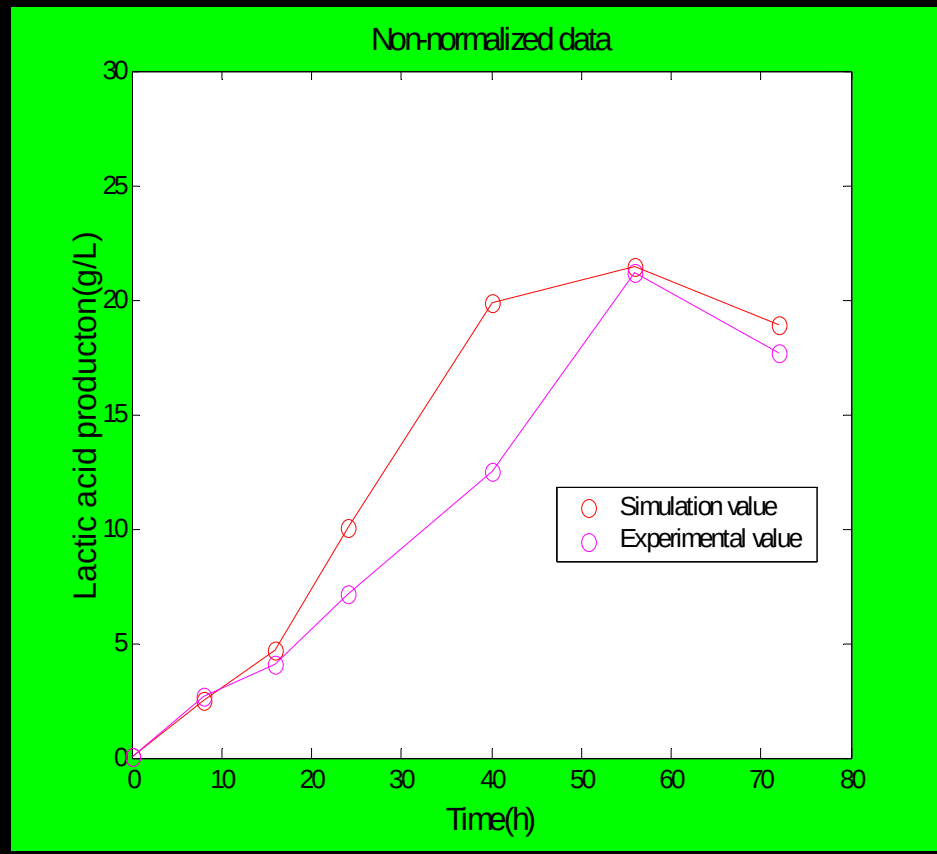
Table 1 : Glucose concentration with normalized and non-normalized data

# Significance of findings

**Comparison curve using normalized and non-normalized data (trained using *newrb* model)**




**Training Data set (pH 4.5, 5.5, 7.5)**
**MSE=0.0109**




**Training Data set (pH 4.5, 5.5, 7.5)**
**MSE=0.1208**

# Effect of normalization

- The effect of normalization on RBF performance.
    i. RBF networks training can be more efficient when normalization of input data is applied
    ii. The RBF networks with non-normalized data are expected to perform well but not efficient as RBF with normalized data

- Basically this means organized data using normalization can removes redundancy, failure to simulation and removes possible revocation of access to any computing device.

# Effect of training algorithm

- Available in MATHLAB® ; Radial basis Networks toolbox. Designed with either 'newrbe' or 'newrb'.

  newrb - sum-square

  Take less time training a network (Bing. H. Chen et al, 2002)

  newrbe - Orthogonal least square;

  can create a network with zero error on training vector (Bing. H. Chen et al, 2002)

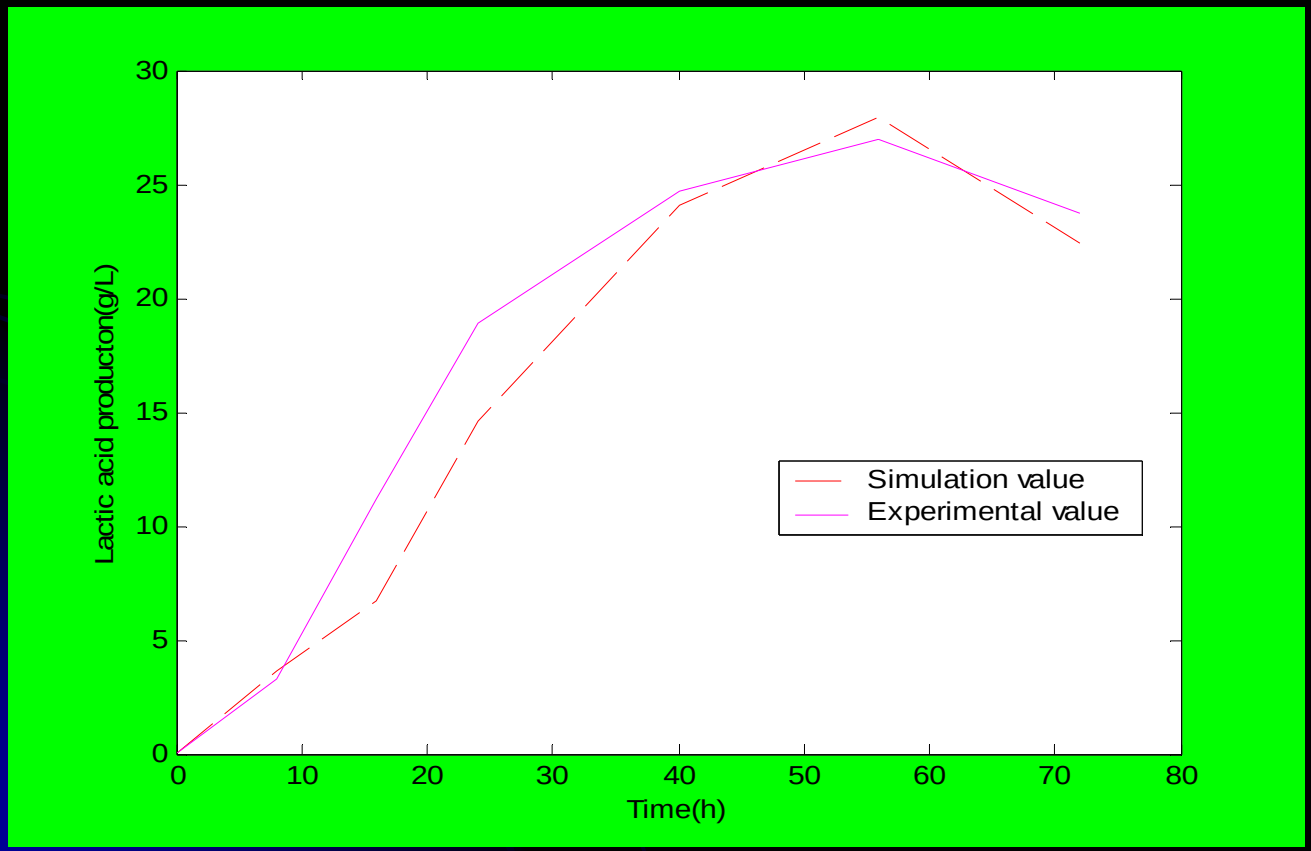
- Experimental data sets for lactic acid production at pH 4.5, 5.5, 6.5, 7.5 and 8.5 were used to train and test the network.

  - 3 data sets for training
  - 2 data sets for testing

# Significance of findings

- *newrb* model

  (a) Relationship between lactic acid production and substrate concentration

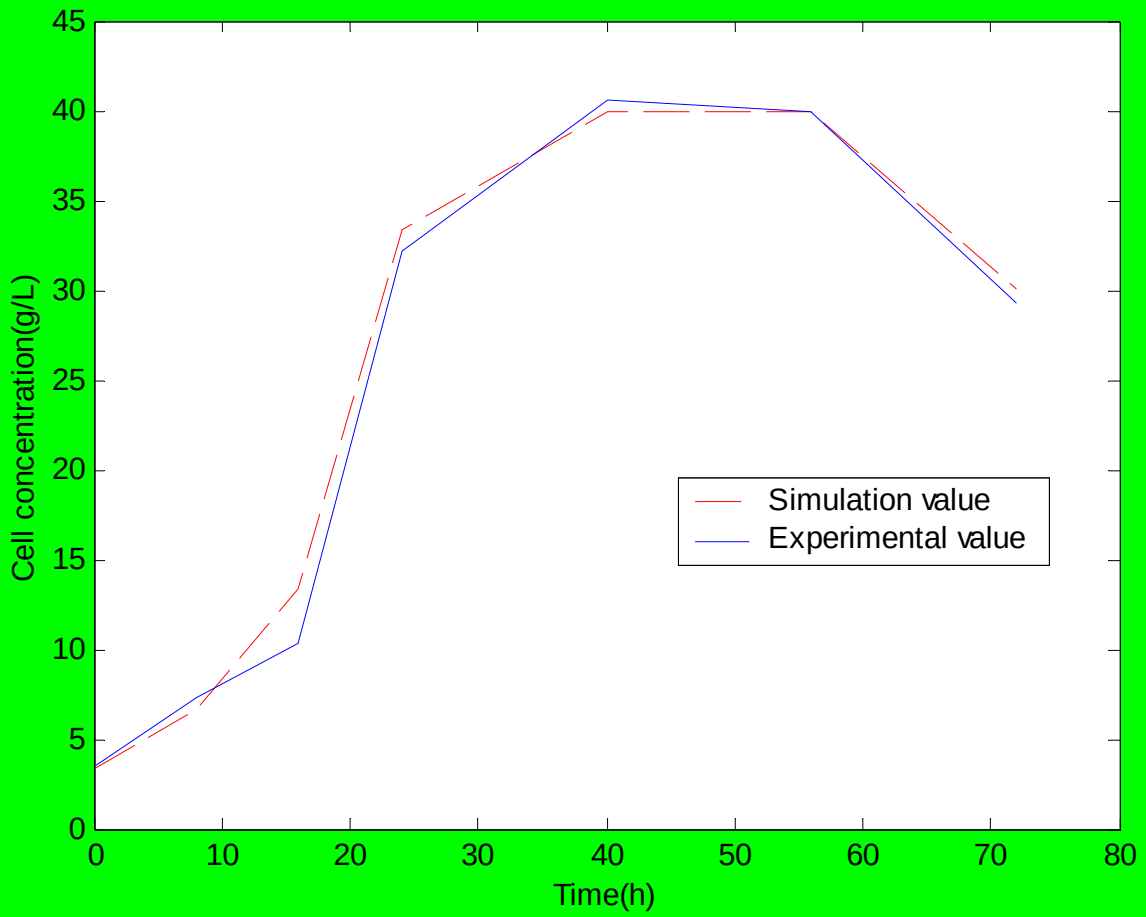



**Training Data set (pH 4.5,5.5,7.5)**

**MSE=0.0109**

**Model structure=1-21-1**

# (b) Relationship between cell concentration and lactic acid production

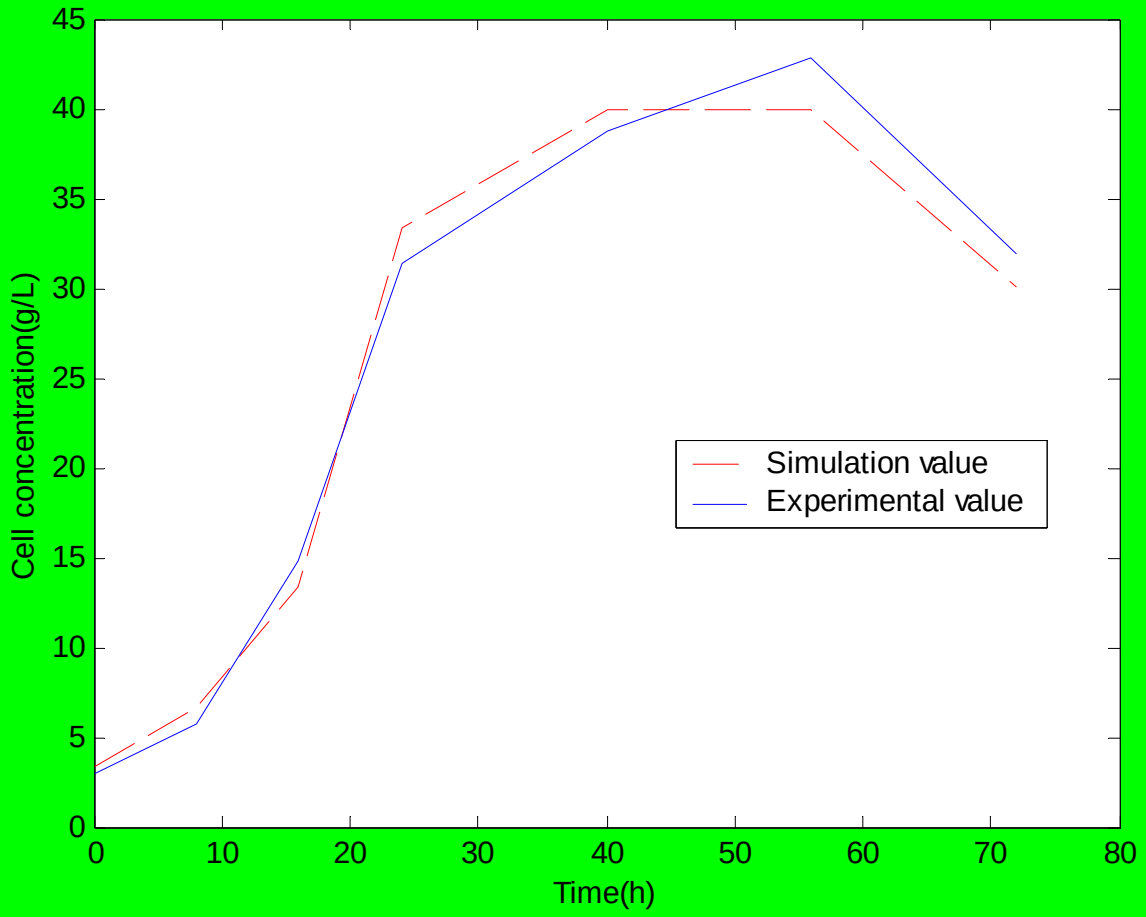



**Training Data set (pH 5.5,7.5,8.5)**

**MSE=0.020358**

**Structure 1-21-1**

# (c) Relationship between substrate concentration and cell concentration



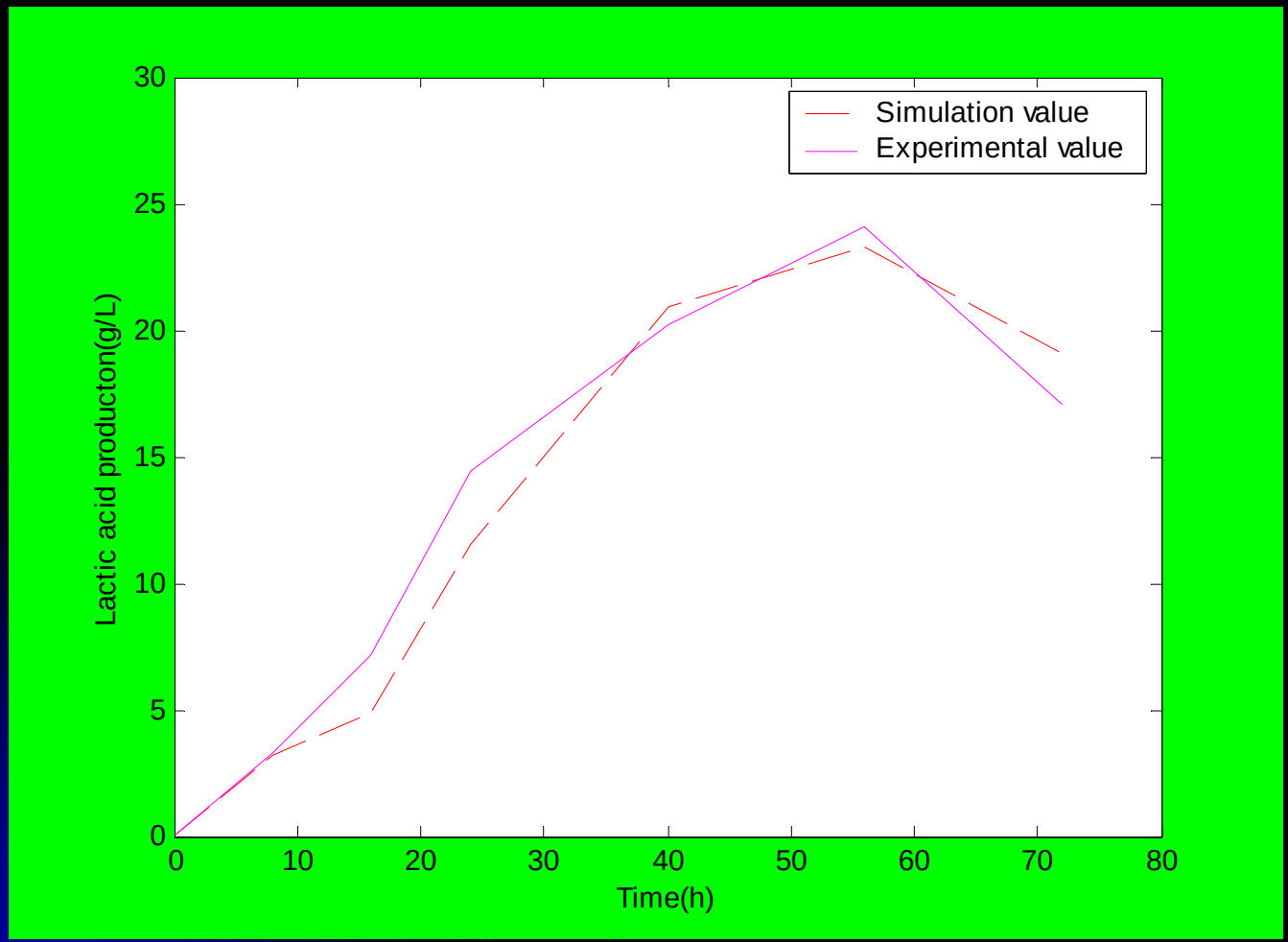

**Training Data set (pH 4.5,5.5,7.5)**

**MSE=0.006918**

**Structure 1-21-1**

- *newrbe* model

(a) Relationship between lactic acid production and substrate concentration

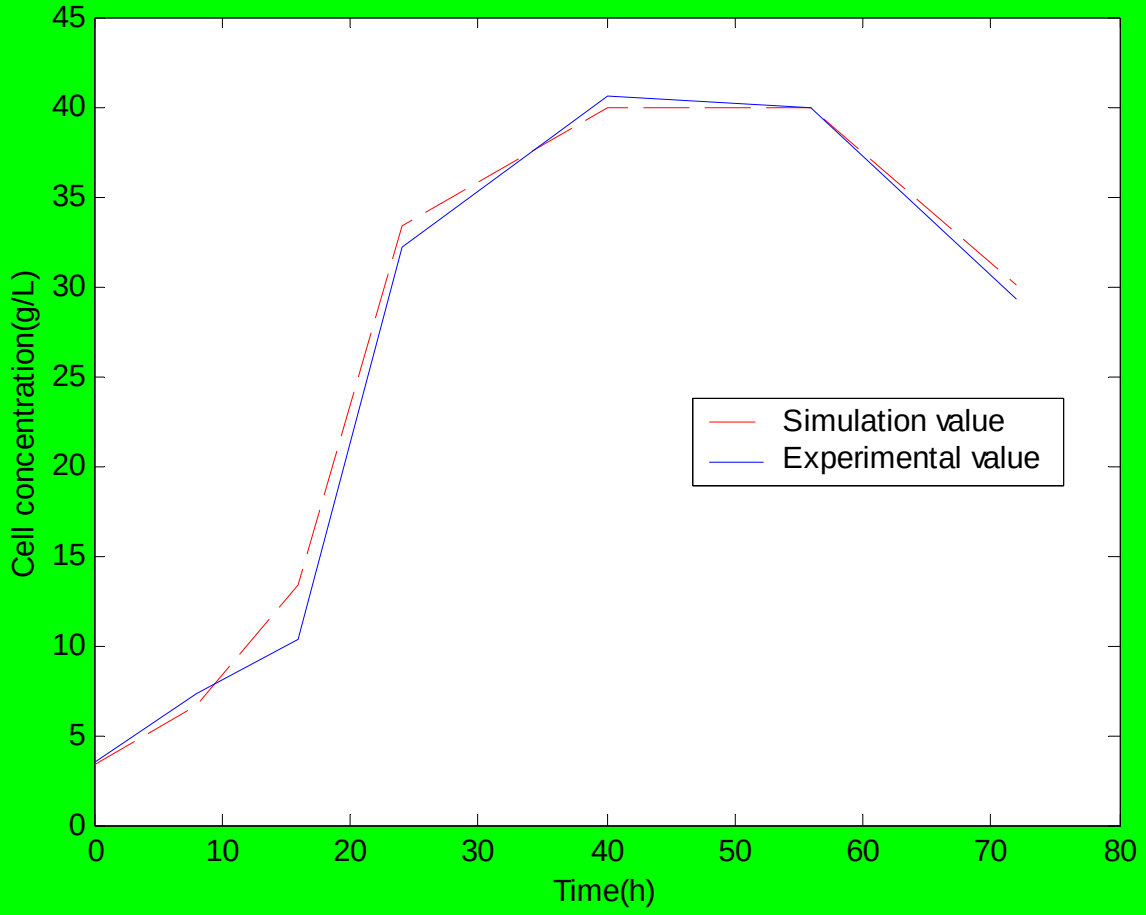



**Training Data set (pH 4.5,5.5,7.5)**

**MSE=0.0109**

**Structure 1-21-1**

# (b) Relationship between lactic acid production and cell concentration

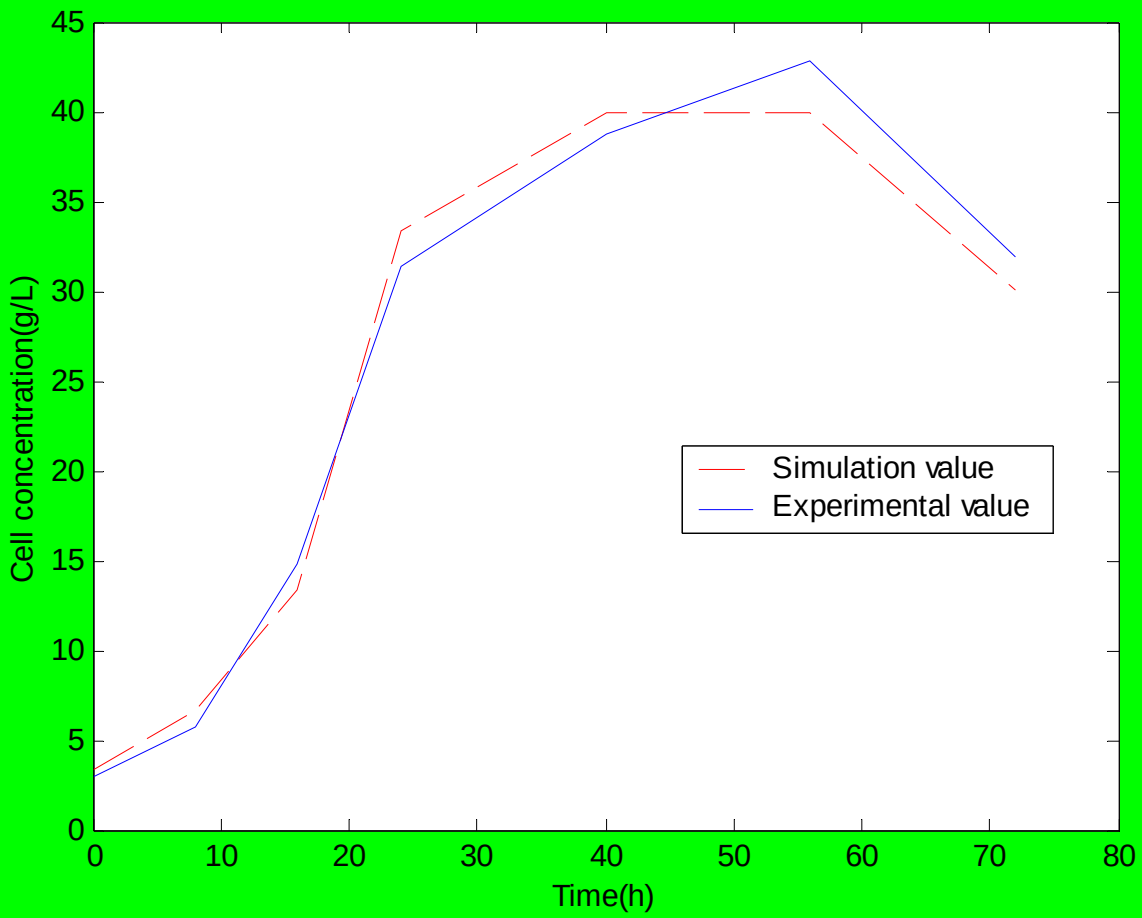



**Training Data set (pH 5.5,7.5,8.5)**

**MSE=0.002035**

**Structure 1-21-1**

# (c) Relationship between substrate concentration and cell concentration




**Training Data set (pH 4.5,5.5,7.5)**

**MSE=0.006629**

**Structure 1-21-1**

Choosing the optimum model:

The best model = The best structure = 1-N-1

| | Newrb model (mse and structure) | Newrbe model (mse and structure) |
|---|---|---|
| Relationship between lactic acid production and substrate concentration | **0.0109** **1-21-1** | **0.0109** **1-21-1** |
| Relationship between lactic acid production and cell concentration | **0.020358** **1-21-1** | **0.002035** **1-21-1** |
| Relationship between substrate concentration and cell concentration | **0.00691** **1-21-1** | **0.006629** **1-21-1** |

# Effect of training algorithm

- Both model structures are able to predict lactic acid production, substrate concentration and cell concentration using experimental data. Thus these modeling approaches can reduce repetition of experiments and process development cost.
- Effect of training algorithm on RBF performance
    i. The proper selection of RBF training algorithm (RBF centers) based on the available data points is very important in order to reflect the RBF accuracy

- When given the initial condition of the process, the RBF models can predict the final product concentration and can be utilized to estimate good starting value of the operating condition

# Conclusion

- Normalization of data before simulation is important to improve the RBF performance
- The different type of training algorithm will give different performance on RBF networks performance. Newrbe model gives minimum MSE.
- Able to use MATHLAB software to develop software sensor for lactic acid production.

# Recommendations

- Investigate the applicability of this modeling approach to predict other types of chemical or bioproducts – definitely assist in optimization process for such product.

# References


- Kapil G.Gadkar, Sarika Mehra, James Gomes,On-line Adaption of Neural networks for Bioprocess Control, Computers and Chemical Engineering 29, 1047-1057 (2005)
- Ani Idris, Wahidin Suzana, Effect of sodium alginate concentration, bead diameter, initial pH and temperature on lactic acid production from pineapple waste using immobilized *Lactobacillus delbrueckii*, Process biochemistry, 1117-1123 (2005).
- Bing H. Chen , John M. Woodley, Wavelet Shringkage Data Processing for Neural Networks in Bioprocess Modelling, Computers and Chemical Engineering 26, 1611-1620 (2002)
- R.Simutis, A.Lubert, Comparative Study on Random Search Algorithms for Biotechnical Process Optimization,Journal of Biotechnology 52,245-246 (1997)
- Mark R.Warnes, Jarmila Glassey, Gary A.Montague, Bo Kara, Application of Radial Basis Function and Feedfoward Artificial Neural Networks to the Escherichia coli Fermentation Process, Neurocomputing 20, 67-82 (1998)

THANK

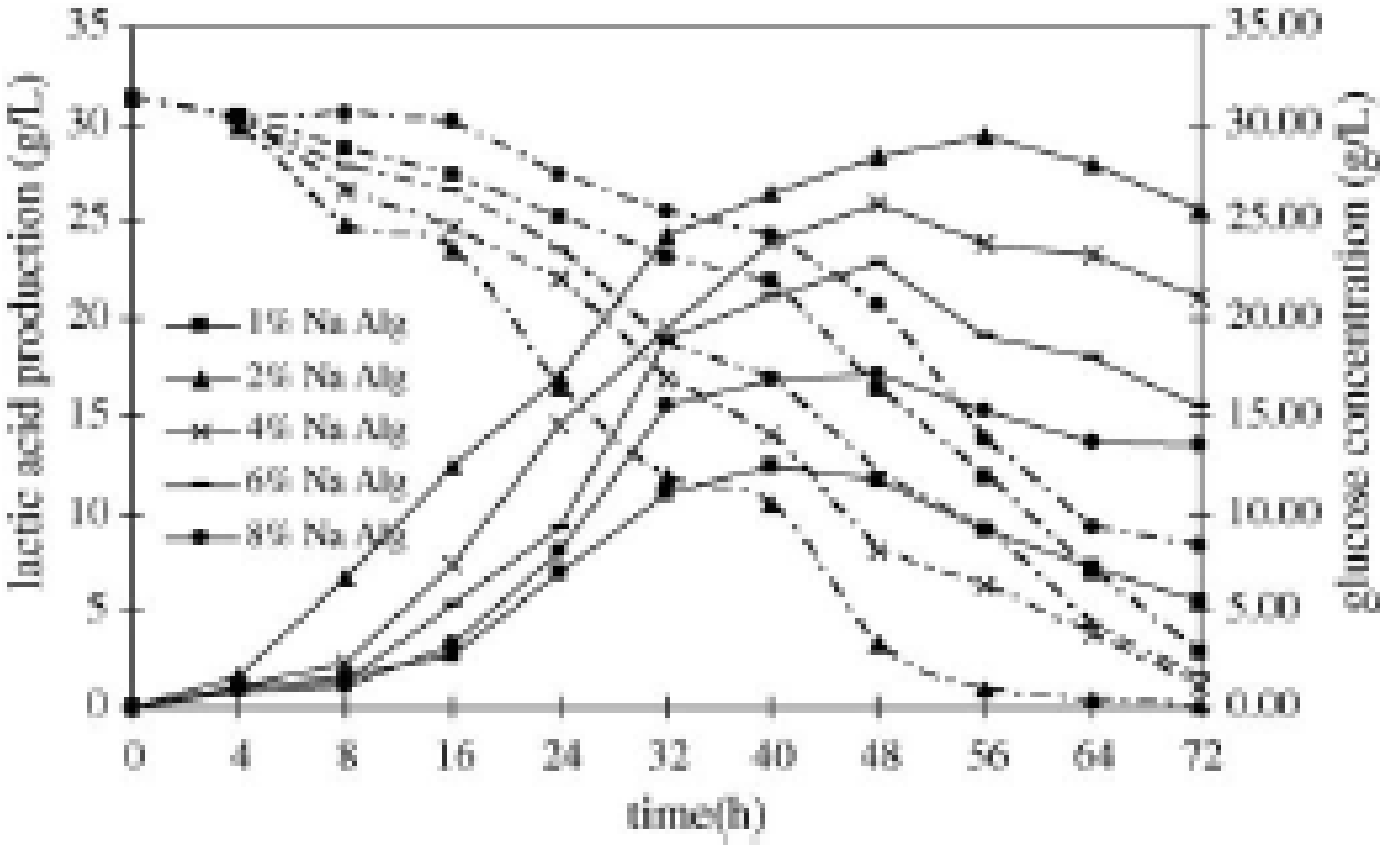



Fig. 1. Effect of sodium alginate concentration on lactic acid production and glucose concentration by Ca-alginate immobilized *L. delbrueckii* ($T = 37$ °C, bead diameter = 1.0 mm, cultivate size = 5.0 g, initial pH = 6.5 and substrate concentration = 31.3 g/L).

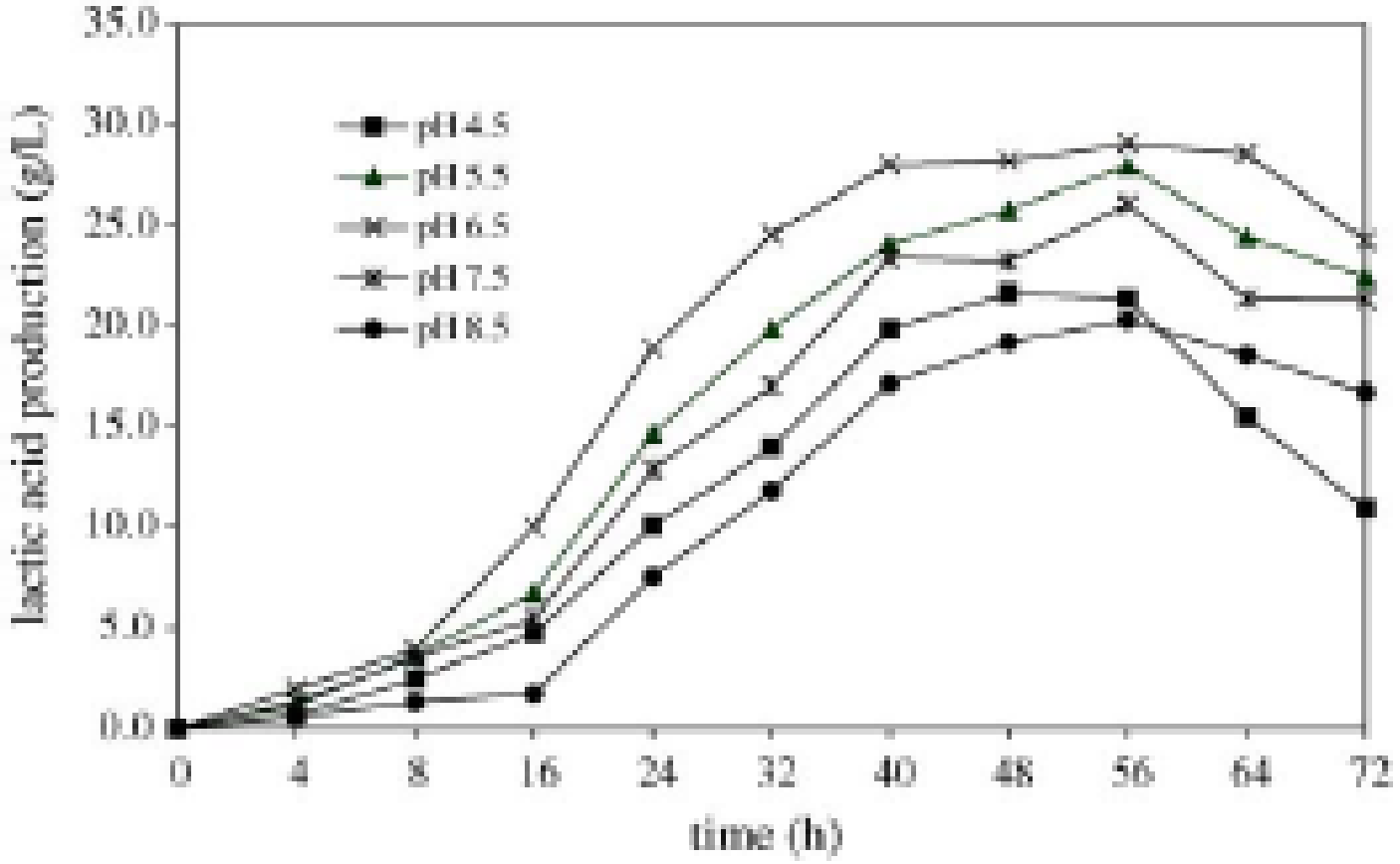



Fig. 3. Effect of initial pH on lactic acid production by Ca-alginate immobilized *L. delbrueckii* ($T = 37\,^{\circ}C$, bead diameter = 1.0 mm, cultivate size = 5.0 g, 2.0% sodium alginate and substrate concentration = 31.3 g/L).