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Genetic Algorithm: Artificial Neural Network Modeling of Process for Flocculation of Lotus Leaf Beverage

[1,2]Libin Xu, [1,2]Yaqi Liu, [1,2]Xia Zhu, [1,2]Jinhua Wang and [1,2]Chao Wang
[1]Key Laboratory of Fermentation Engineering (Ministry of Education),
HuBei University of Technology, WuHan 430068, China
[2]Research Center of Food Fermentation Engineering and Technology of HuBei, WuHan 430068, China

Abstract: The process for flocculation of lotus leaf beverage by using soyabean protein was investigated in this study. Processing factors were soybean heating temperature, NaOH concentration and soybean heating time. Genetic algorithm-artificial neural network model was used to optimize the different influencing factors on flocculation. Back-propagation network was chosen as the network model. Weights and basis of network was optimized using genetic algorithm. The developed GA-ANN which included 9 hidden neurons could predict clarifies degrees of lotus leaf beverage with correlation of 0.94. The results indicating that GA-ANN model provided an accurate prediction for lotus leaf clarify beverage degrees.

Key words: Lotus leaf beverage, artificial neural network, genetic algorithm, flocculation, clarify degrees

INTRODUCTION

Nelumbo nucifera (Gaertn) is a perennial aquatic crop grown which belongs to Nymphaeaceae plants. Almost all parts of *Nelumbo nucifera* (Gaertn) leaves, flowers and seeds have been purposely utilized to various medicine purposes in Chinese herbal medicine. In particular, the leaves are known for antioxidant properties and also used to clean heat, resolve summer heat and stop bleeding. Recently, lotus leaf was made into beverage with a lot of impurities and causing a turbidity phenomenon.

Turbidity phenomenon always occurred during the process of tea, wine and vinegar production. The main reason of turbidity phenomenon is tannin compounds, such as polyphenols. Flocculation method is the main application in China. In order to improve the clarity and quality of the lotus leaf beverage, the flocculant of soyabean protein was used to flocculate lotus leaf beverage in this experiment. The complex reaction between protein and polyphenols is main principium during the flocculation. The flocculation rate as flocculation effect standard was used and the main parameters to estimate the different influencing factors on flocculation. The purpose of this work was to investigate the effect of process parameters (soybean heating temperature, NaOH concentration, soybean heating time) on soyabean protein used to flocculate lotus leaf beverage.

Artificial neural networks are mutually connected by large number of neurons. ANN simulated the process of human brain disposing the information and nonlinear transformation. Owing to the neural network has strong learning function. Therefore, it has broad applicability in the process of data fitting and solve many difficult problems which using the traditional method can not completed. ANN models have been classified in to supervised network and unsupervised network. Supervised network learning based on adjusts weights by compares with experimental values and predicted from a large number of training data. Unsupervised network learning based on adjusts weights by themselves to achieve the required results. Supervised network are suitable for prediction and control of food processing operation (Jindal and Chauhan, 2001; Smith, 1996). A multilayer feed-forward networks has strongly learning ability and has been used to solve many problems of food fermentation. Applications of ANN models include extrusion processes, fermentation, drying processes, etc. (Bardot *et al*., 1994; Dornier *et al*., 1995; Lertworasirikul and Saetan, 2010). Besides, artificial neural network has been already applied to the prediction and classification (Kruzlicova *et al*., 2009; Mohebbi *et al*., 2011; Fathi *et al*., 2011).

Genetic algorithm imitated Darwin's evolution theory which was simulated natural evolutionary process to search the optimal solution by natural selection and genetic mechanism. Owing to the optimum method and global search strategy of the genetic algorithm rely on the process of calculation without any other specialist knowledge. It was affected by objective function and

Corresponding Author: Chao Wang, Key Laboratory of Fermentation Engineering (Ministry of Education),
HuBei University of Technology, WuHan 430068, China

corresponding fitness function. Therefore, this study provide a general framework for modeling the process of flocculation of lotus leaf beverage.

In this study, the main purpose was to utilized artificial neural network model using genetic algorithm to modeling the process for flocculation of lotus leaf with four different conditions (soybean heating temperature, soybean heating time, NaOH concentration).

MATERIALS AND METHODS

Samples preparation: Sample of the pulverized leave of *N. nucifera* (Gaertn) was purchased from Honghu, China. The soybean was obtained from Zhongnan Chain Department Stores (WuHan, China).

Chemicals and reagents: Sodium hydroxide (NaOH) and hydrochloric acid (HCl) were of analytical grade (Sinopharm Chemical Reagent Co., Ltd., China). Reverse osmosis Mill-Qwater (Millpore, USA) was used for all solutions and dilutions.

Instrumentation: Clarify degrees, as a standard of flocculation effect was measured by using a model UV (Ultraviolet spectrophotometer) -2450 (Shimadzu, Japan) at 570 nm. The pH value of lotus leaf extraction content was continuous monitoring, using a Model 320 pH m (Mettler Toledo Instruments (Shanghai) Co., China).

Experiment method: The soybean was soaked with boiling water (1:10, m/v) for 2.5 h, then made into soybean milk. The soybean milk with appropriate NaOH was heated in different temperature for 0-50 min. The experiment was designed to study the different factors of added content of NaOH, heated temperature and time. Subsequently, the soybean milk at room temperature was clarifier for later experiment. Weights 5 g sample of the pulverized leave of *N. nucifera* (Gaertn) was extracted with water (1:20, m/v) by sonicating for 15 min and filtering through a 0.04 mm filter for further experiment.

Artificial neural network: Artificial neural network as a mathematical non-linear statistical system which is emulating biological neural network and utilizing each connective neurons to exchanged data. Back-propagation network is used widely in ANN and learning a complex relationship among a number of variables. BP network is a multilayer feed-forward network which according to the error back-propagation algorithm to trained and learned. BP network stores up a large number of mappings between input and output without reveal the mathematical equations. Back-propagation network according to adjust the weights and thresholds continuously to reduce the square error. It consists of input layer, hidden layer and output layer. It constitutes a feed-forward neural network system by connecting each adjacent neuron fully. In this study, 10 neurons in hidden layer with the lowest error were chosen. Each input neurons according to data, multiplying their corresponding weights and putting the result in nonlinear or linear activation function (f). And then summing the values and finally adding bias, mathematically:

$$y_j = \sum_{i=1}^{n} f(w_{ij}x_i) + b_j$$

where, x and y are numbers of the input and output of neuron, respectively, n is number of inputs, w_{ij} is the weights and b_j is the bias.

In this study, the hyperbolic tangent function of S type was used in hidden layer while a linear function was applied in the output layer. The put layer consists of three neurons (soybean heating temperature, soybean heating time, NaOH concentration) and the output layer contains one neurons (lotus leaf clarify degrees).

Therefore, 75 samples data were analyzed in this study. For convergence and avoiding the over-learning of the ANNs, the available training data were divided into three subsets: training (60%), validating (20%) and testing data (20%). The first partition was used to training the network. The second one was used to estimate the performance of the network during the training. The last partition was used for evaluating the performance of the trained network on new data that was never seen during the training. Mean squared errors (MSE) and regression coefficients (r^2) between predicted value and experimental values were used as the performance for modeling.

Genetic algorithm: Genetic algorithm roots in biological evolution law (survival of the fittest, survival of the fittest) of randomly evolving and searching method. The main feature of it is operating on the structure of the objects directly; having global search ability can automatically found superior individuals without rules. The structure of BP neural network and individual length is decided by the numbers of input and output. Genetic algorithm is used to optimize the BP network weights and bias by calculation of the fitness function. The individuals could be operated by quasi-genetic operations of selection, crossover and mutation. The select operator is according to fitness function chooses the best individuals. Crossover and mutation operator used to enhance the GA ability by intermittently inject any random points which allows escaping from local optima.

During the learning process, learning rate and momentum sets were used to resolve the convergence speed slowly. In this study, networks with 0.2 and 0.3 learning rate and momentum have minimum MSE and maximum r^2. The default initial population chromosomes are 60. Therefore, the population size of 50 was chosen in this study. The crossover and mutation ratio of 0.5 was randomly generated, yet in this study adjusted at 0.5 and 0.4. The ANN modeling and GA optimization were performed by MATLAB 7.1.

RESULTS AND DISCUSSION

This study studied the process for flocculation of lotus leaf by soyabean protein in different NaOH concentrations and soybean heating temperatures. The study on the effects of process parameters on lotus leaf clarify degrees showed that the best result occurred in 100°C heating temperature and 0.01% concentration at 25 min.

Back-propagation network according genetic algorithm optimized has the lowest prediction errors with Mean squared errors of 7.3291 and predictions for each test data has the highest regression coefficients of 0.94. The experimental values of lotus leaf clarify degrees versus genetic-artificial neural network predictions for each test data were plotted for estimating the performance of the network (Fig. 1). Genetic algorithm-artificial neural network (GA-ANN) modeling of process for flocculation of lotus leaf with the three effect factors revealed high accuracy and an acceptable agreement which could be applied in a computer program for online prediction of the lotus leaf clarify degrees.

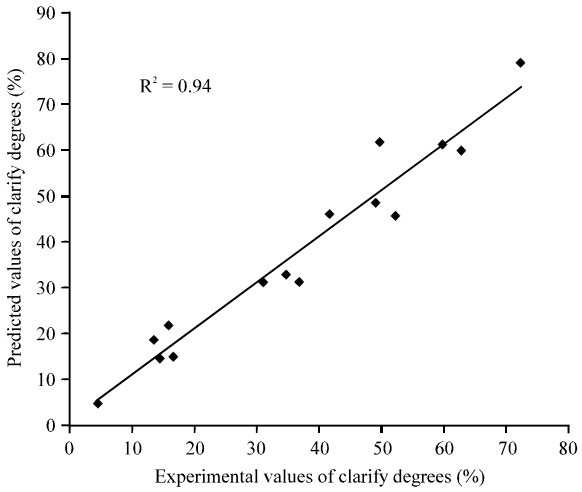

Fig. 1: Experimental versus predicted values of clarify degrees using GA-ANN model

CONCLUSION

Artificial neural network by using genetic-algorithm optimized according to data training for flocculation of lotus leaf with the three effect factors have a high accuracy. The results showed remarkable performance and GA-ANN probably used for prediction and control of flocculation process of lotus leaf by using soyabean protein. It conduced to the other ranges of beverage flocculation for ANN model developed.

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