**Introduction**

*P. eryngii* is commonly known as king oyster mushroom or king trumpet mushroom, highly valued for its superior texture, flavour and quality [1]. It is commonly cultivated in Europe, Middle East, and North America as well as in parts of Asia [2]. It is both rare medicinal and edible mushroom [3-5]. Modern pharmacological studies indicate that *P. eryngii* contain highly valued nutritional ingredients [6,7], as well as medicinal ingredients with medical activities including antioxidant [7-9]; cholesterol-lowering, cardiovascular diseases preventative [10-12] and antitumor activities [13-15]. Moreover, the polysaccharide of *P. eryngii* combined with bifidobacteria can not only improve the digestion function but also beautify human faces [16]. Therefore, *P. eryngii* are welcome to many consumers. However, in the process of cultivating *P. eryngii* under the influence of climate and geography, the output and quality are obviously unstable. In addition, the different culture conditions in the incubation room have a significant impact on the growth of *P. eryngii* stipe. And most companies have no scientific methods but only depend on experience to control cultivate conditions of *P. eryngii*. In the process of production, we found that the culture conditions (temperature, wind speed, carbon dioxide concentration and relative humidity) of *P. eryngii* have a significant effect on the growth length of *P. eryngii* stipe. In order to reduce the production cost and raise production, the conditions of cultivating *P. eryngii* must be scientifically and reasonably controlled.

*ANN* has the capacity to handle the linear and nonlinear information automatically [17,18] and is composed of a large number of processing units. *ANN* is used to process information and store knowledge by simulating human brain [19]. But it does not truly portray human brain network, only to simplify and simulate the information and knowledge. At present, the *ANN* model as a mathematical tool has been widely used in chemistry, engineering, economic administration, transportation and other fields.

**ARTICLE INFO**

Received: Monday, October 09, 2019
Published: Monday, October 17, 2019


**Keywords:** Artificial neural; *Pleurotus eryngii*; Culture conditions

**Abstract**

In this paper, the artificial neural network (ANN) model was established to predict the growth state of *P. eryngii* in the culture process. Temperature, wind speed, carbon dioxide concentration and relative humidity were set to enter into the ANN, the length of the *P. eryngii* stipe were set to be the output. Using genetic algorithms (GA) to optimize the structure and learning parameters of ANN. The developed genetic algorithm-artificial neural network (GA-ANN) which include 8 and 4 neurons in the first and second hidden layers respectively, gives the lowest mean squared error (MSE). The correlation coefficient of predicted value and experiment value about *P. eryngii* stipe were 0.996 and 0.994, respectively. In addition, through sensitivity analysis it can be found that within a certain temperature range the impact of wind speed on the growth state of *P. eryngii* stipe is most obvious and following carbon dioxide concentration and relative humidity. The result showed that the developed GA-ANN model was suitable for predicting the growth state of *P. eryngii* stipe during the culture process.

**Practical Applications:** The growth of *P. eryngii* is a nonlinear process, which is affected by many factors. The main purpose of our study is to develop a model to predict the growth of *P. eryngii* stipe. It provided guidance for *P. eryngii* industrial production, reducing costs and increasing production.
fields. For instance, [20] has applied recurrent neural networks and profiles method to predict furfural and 5-hydroxymethylfurfural content of fermented lotus root the [20]. And [21] has used ANN to assessment computational aesthetics of photos quality. Topuz used ANN to predict moisture content of some agricultural products such as hazelnut, bean and chickpea [22]. Panagou and Kodogiannis made use of neural networks to model microbial growth in food and animal feed [23]. However, the application of mathematical models based on ANN in predicting the growth length of *P. eryngii* is relatively fewer than in other processing fields.

Genetic algorithm is a new random search and optimization method developed rapidly in recent years, its basic idea is based on Mendel's genetics and Darwin's theory of evolution by natural selection and genetic mechanisms to search for the optimal solution. Genetic algorithm is characterized by self-organizing, self-adaptation and intelligence [24,25]. Therefore, it can be used to solve complex and unstructured problems and effected by the corresponding fitness and objective function. Genetic algorithms attempt to find an appropriate algorithm to correct adverse conditions for optimizing the neural network. Based on the self-adaptation of genetic algorithm, neural networks would be designed in order to obtain a satisfactory convergence and adaptability.

Due to the growth of *P. eryngii* is a nonlinear process and is affected by many factors. Therefore, the main purpose of this study is to develop a model to predict the growth length of *P. eryngii* stipe. It provided guidance for *P. eryngii* industrial production, reducing costs and increasing production.

**Materials and Methods**

**Preparation of Spawn**

Sawdust spawn was prepared by inoculating sawdust substrate consisting of sawdust and wheat at a 3:2 ratio with *P. eryngii* (Acc no.50894.) preserved in the microbiology laboratory in China Microbial Culture Collection. Culturing was performed at 22 °C until spawn running was apparent on the substrate.

**Cultivation Methods**

Substrate was prepared by mixing corn cobs, sawdust, bagasse, wheat bran, soybean meal, corn flour, lime, calcium hydroxide and water content with this proportion (30%, 20%, 20%, 16%, 8%, 4%, 1.15%, 0.85% and 64%, respectively). The prepared substrate was packed into polypropylene bags and the weight is 1.3 kg. Afterwards, they are sterilized and inoculated with 30 g of the sawdust spawn of *P. eryngii*. Culturing is carried out in an incubation room at 20 °C, until the polypropylene bags are full of mycelial after removal of the caps to enable fruit-bodies to emerge. At this time, the incubation room temperature was adjusted to 22 °C for another 4 d ~ 5 d. The next step is to deal with the mushrooms with two mushroom heads in each polypropylene bags. And then, the prepared polypropylene bags are respectively put into biochemical incubator which have five different gradient of temperature (7 °C, 12 °C, 17 °C, 22 °C). Wind speed (1 m/s, 2 m/s, 3 m/s, 4 m/s), concentrations of carbon dioxide (500 ppm, 1000ppm, 1500ppm, 2000ppm) and relative humidity (65%, 75%, 85%, 95%) are cultured until sampling. Triplicate *P. eryngii* are sampled.

**Artificial Neural Networks**

Multilayer artificial neural network consists of input layer, hidden layer and output layer [26]. The input layer is responsible for receiving information from the outside world, the output layer is responsible for the results of post-processing the output of the system, the hidden layer has a greater impact on the prediction accuracy of ANN model. Each neuron receives the information from the data processing of the previous layer, and neurons of each layer have the same transfer function, but each neuron is calculated independently. After calculation is completed, the results were passed to the next layer. Subsequently, the weights and thresholds are adjusted during the training process using gradient descent algorithm and the optimal number of iterations is determined by minimum average absolute error. Genetic algorithms is applied to optimize the artificial neural networks, which is an evolutionary algorithm and a method of searching in a simulated natural evolution process.

In this process, through genetic manipulation, selection, crossover and mutation are conducted to select fitness environment for the individuals of the population, optimizing generation to generation and the fittest surviving, until the optimal performance parameter set is selected. Before the start of the training, the back propagation neural network parameters of step length, momentum and the number of hidden layer are set as 0-1, 0-1 and 3-21 respectively [27]. The trained goal of genetic algorithms is to find minimum mean square error between experimental value and predictive value and make the performance of the neural network achieve the best. In this study, 256 samples are divided into three parts randomly, 128 samples for train, 64 samples for cross and the last 64 groups as the new data to evaluate the performance of the artificial neural network model.

The topology of BP-neural network prediction model is a four-layer back propagation network. The input layer consists of four neurons (temperature, wind speed, carbon dioxide concentration and relative humidity) and the output layer contains two neurons (the length of A cm and B cm). But the number of hidden layer neurons is set by repeated training and experiment. Eventually the BP-neural network prediction model will obtain its best predicted performance when the number of the first and second hidden layers is 4 and 2, respectively. At this time the optimal iteration number is 15, and the MSE reaches the stable value of 0.0012. Until you get a satisfactory result before this process is the need to be repeated screening [28].
Statistical Treatment

P. eryngii samples grown well and strong are chosen to be cut open along the central axis. The pilei are removed remaining the stipes measured following. Experiments were performed in triplicates. Data were analyzed in OriginLab-8s (OriginLab Corporation, USA). Mean values were determined for each case.

Results and Discussion

Bp- Artificial Neural Network

Based on repeated BP-artificial neural network testing and training of artificial neural network, the structural parameters were to achieve optimal. The predicted values of the length of P. eryngii stipe for training set obtained using the optimal architecture of the BP-artificial neural network and their corresponding experimental values are presented. The fitting curve of desired output and ANN output were shows that predicted values and experimental values have the very good fitting through the optimized BP-artificial neural network. Earlier, [29] used artificial neural networks to predict the antioxidant activity of tea. The results show that artificial neural network is a very effective tool for predicting the antioxidant activity of tea samples. Some researchers have also used ANN to predict the storage quality of green peppers. The results also show that the method has high fitting accuracy and is a very promising prediction method [30]. Some researchers have even used ANN to build prediction and classification models for wine and soy sauce [31,32]. Among these similar conclusions, it is not difficult to find that ANN is a very promising prediction tool.

Optimized Ann Model Performance Data Set

Currently there have been no uniform standard for the current set of relevant parameters specific ANN mathematical model [33], therefore, the use of ANN to predict the relevant parameters ANN mathematical model needs to repeat test and optimization. By repeated selection and experiments, the step, weights and the number of neurons is set, so that to achieve optimal ANN. A good mathematical model has a high R2 and a low MSE [34]. The predicting parameters of growth length of P. eryngii stipe are obtained by the optimized BP-ANN model. It can be seen that R2 of the prediction model for the A value and the B value are 0.9963 and 0.9947, respectively. Similarly, we obtained lower MSE values of 0.0736 and 0.1271, respectively.

Sensitivity Analysis

The purpose of analysis the sensitivity of artificial neural network is to investigate the relationship between the network input and output variables. The most important factors for growth length can be quickly and effectively screened out by the known input conditions. This analysis suggests that how to optimize different models from the known input variables [35]. Among four input factors temperature is the most important factors. In the previous study, it was also proved that temperature is the most important factor affecting the growth of P. eryngii [36-38]. In these four input variables of temperature, wind speed, carbon dioxide concentration and relative humidity, the growth length of P. eryngii stipe is the most sensitive to temperature and following wind speed, carbon dioxide concentration and relative humidity.

Conclusion

The above study indicates that artificial neural network has proven to be a powerful tool in learning the relations between the culture conditions as input and the P. eryngii stipe length as output. Therefore, it is possible to use BP-based artificial neural network to design better culture environment of growth of the P. eryngii stipe. It provides guidance for increasing the production of P. eryngii and saving costs of culture process.

Acknowledgment

The work described in this article was supported by Postgraduate Research & Practice Innovation Program of Jiangsu Province (KYCX18_1766). Yangtze River Delta Project of Shanghai (18395810200), Forestry science and technology innovation and extension project of Jiangsu Province (No. LYK[2017]26), National first-class discipline program of Food Science and Technology (JUFSTR20180509).

References


ISSN: 2574-1241
DOI: 10.26717/BJSTR.2019.22.003699
Jian Juab, Biomed J Sci & Tech Res

This work is licensed under Creative Commons Attribution 4.0 License
Submission Link: https://biomedres.us/submit-manuscript.php

Assets of Publishing with us
• Global archiving of articles
• Immediate, unrestricted online access
• Rigorous Peer Review Process
• Authors Retain Copyrights
• Unique DOI for all articles

https://biomedres.us/