Research on Optimization of Sea Rice Biscuit Based on BP Neural Network

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Abstract. Sea rice is rich in dietary fiber and selenium, and has the characteristics of low fat and low calories. The main raw material of this paper is sea rice noodles. The sensory evaluation, chewiness and hardness of functional biscuits are the main inspection criteria. Through orthogonal experiments and the use of BP neural network modeling and prediction, the relationship between the three influencing factors of the model and sensory evaluation indicators Carry out modeling and predictive analysis to guide the optimization research of product formula and improve efficiency. The difference between the three predicted values and the actual indicators is small, which are -0.0073%, -0.0091%, and 0.3225%, respectively, which have a good prediction effect.

Keywords: Sea rice, biscuits, Prediction, BP neural network.

1. Introduction
China has studied sea rice for 33 years. Sea rice (saline-alkali-tolerant rice) is bred in saline-alkali soil or seaside areas. Sea rice has a reddish red color and is rich in anthocyanins [1]. Sea rice is known as "medicine rice". It is rich in dietary fiber, anthocyanins and IP6, and is also rich in selenium, zinc, calcium and other elements. Sea rice can increase the value of beneficial bacteria in the intestine, and moisturize the bowel. It can also improve human immunity and has obvious inhibitory and protective effects on cancer.

Nowadays, people's dietary needs are not only satisfied with satiety, but tend to focus on health functions such as physical fitness and immune enhancement. "Medicine tonic is not as good as food tonic" has become more people's diet concept [2]. With the society’s medicinal value and development potential, while meeting people’s dietary needs, it also plays a unique health care function of reducing fat and fighting cancer.

With the progress of society and changes in the environment, harmless, healthy, and nutritious foods will be loved. The development of sea rice on saline soil has obvious sea rice weight loss biscuits is timely and has broad prospects.

Artificial neural network (ANN) is abbreviated as neural network. It was proposed by Rumel hant and McClelland in 1986. It is currently one of the most widely used neural networks with themost
achievements. There are more than 60 commonly used neural networks. The Multiple-layer feed forward network (BP network) based on the Back-propagation algorithm can simulate the interaction between the real world and objects of the biological nervous system. Artificial nerve which network processing information is to train the neural network through the information sample, so that it has the memory and recognition ability of the human brain, and completes the function of famous information processing. It does not need any prior formulas, it can automatically summarize the rules from the existing data, and obtain the internal laws of these data. The units to be processed are connected to each other according to a certain logic to form a computing system. It has good self-learning and self-learning. Adaptability, parallel processing and non-linear shape transformation capabilities. If the signal output by the output layer does not match the expected output, then go to the next process, which is the back propagation of the error. The advantage of that is to solve the modeling of nonlinear problems, with strong input and output nonlinear mapping capabilities, and is now widely used in industries such as intelligent manufacturing, data modeling and analysis. Its outstanding advantage is the strong nonlinear mapping ability and flexible network structure [3-5]. The BP neural network is particularly suitable for non-deterministic reasoning, judgment, identification and classification problems with complex causality. For any set of random and normal data, artificial neural network algorithms can be used for statistical analysis, fitting and prediction.

The research uses orthogonal experimental data fitting and takes the main component factors as the input of the BP neural network, the actual sensory evaluation indicators as the output of the BP neural network, which sets the hidden layer nodes, and after training, constructs the best BP neural network model. This model is used to obtain the simulation formula of sea rice biscuit, which provides a means of rapid verification experiment simulation for obtaining product formulas for bakery enterprises, and also provides a certain theoretical basis for the research of incremental optimization and prediction of bakery products.

2. Based on BP neural network algorithm, establish a mining model

2.1. Model data sample extraction principles

There are several basic principles for sample extraction. First, variables that greatly affect the result output and are easily detected or extracted to be used as input variables. Second, try not to have too much correlation or non-correlation between input and output. At the same time, according to the nature of input and output, they are divided into two categories: character variables and numeric variables. The latter can be divided into discrete variables and continuous variables.

Character variables can only be processed by the network when they are converted to discrete variables. Third, it is necessary to use the signal processing or feature extraction technology in the original data to extract the parameters that can reflect the network characteristics as input, that is, to perform normalization processing.

2.2. Experimental method

Equipment:
TMS-PRO texture analyzer: FTC company; DTF-A500 electronic balance: Fuzhou Huazhi Scientific Instrument Co., Ltd.; SM-503 oven: Xinmai Machinery Co., Ltd.; electric heating constant temperature blast drying oven: Shanghai Yuejin Medical Equipment Co., Ltd.

Preparation of sea rice noodles:
Sea rice → soak in clean water for about 1-2h → rinse, select → dehydrate → hot-air drying for about 4-5h → crushed by a grinder → sieved (50 mesh sieve, aperture 0.250mm) → sea rice noodles → stored in the refrigerator Medium → Standby [6].

Basic biscuit recipe:
Sea rice noodles 100% (based on sea rice noodles, and the rest of the auxiliary materials are calculated in proportion to the weight of sea rice noodles), powdered sugar 15%, low-gluten flour 20%, edible vegetable oil 20%, egg liquid 3%, honey 2%, milk 2%, baking soda 1.1%, konjac flour 0.2%.
**Experimental method:**
After the biscuits to be made, sensory judgment and analysis of the shape, color, taste, tissue state and flavor of the biscuits are required. The sensory judgment and analysis team which is composed of ten people who are studying food. According to GB/T 20980 Biscuit, the sensory indicators of medium-toughness biscuits are discussed to determine the inspection criteria (see Table 1), and the final sensory score is the average of all scores [7].

| Project                        | Standard                                              | Fraction |
|--------------------------------|-------------------------------------------------------|----------|
| **Form (15 points)**           | Complete shape, uniform thickness, smooth surface     | 10-15    |
|                                | Incomplete shape, broken, uneven                      | 5-9      |
|                                | Seriously uneven and broken surface                   | 0-4      |
| **Color (15 points)**          | Reddish brown, uniform color                          | 10-15    |
|                                | Basically, uniform color                              | 5-9      |
|                                | Uneven color and burnt phenomenon                     | 0-4      |
| **Taste (30 points)**          | Crispy, delicate and non-sticky in the mouth          | 20-30    |
|                                | Crispy, delicate, slightly sticky                     | 10-19    |
|                                | Loose or stiff entrance, sticky teeth                 | 0-9      |
| **Organizational status (20 points)** | Uniform structure, layered section                  | 15-20    |
|                                | Clear structure and rough organization                | 9-14     |
|                                | The texture is rigid, the section structure is not clear, and there are large holes | 0-8      |
| **Flavor (20 points)**         | Sweet taste, strong rice fragrance, no peculiar smell | 15-20    |
|                                | Too sweet or lightly sweet, with a slight rice fragrance, no peculiar smell | 9-14     |
|                                | Too sweet or too light, no rice fragrance, slightly peculiar smell | 0-8      |

TMS-PRO texture analyzer was used to test the chewiness and hardness of sea rice slimming biscuits. The cylindrical probe diameter was 4mm. The instrument was set before the test. The specific setting items are as follows: The test method is compression. The speeds before, during and after the test are 60mm/min, 30mm/min, and 60mm/min respectively. The chewiness and hardness of the biscuit are expressed by the data obtained after the test and the peak value of the curve [8].

On the basis of single factor pre-experiments, orthogonal experiments were carried out with low-gluten flour, edible vegetable oil, powdered sugar and baking temperature as factors. Taking the sensory evaluation, chewiness and hardness of the biscuits as the main inspection criteria, the orthogonal experiment was carried out according to the $L_4^{(3^4)}$ orthogonal experiment factor level table (see Table 2).

| Level | A low-gluten flour | B powdered sugar | C Edible vegetable oil | D baking temperature |
|-------|--------------------|------------------|------------------------|----------------------|
| 1     | 20%                | 20%              | 15%                    | 150°C/130°C          |
| 2     | 25%                | 25%              | 20%                    | 170°C/130°C          |
| 3     | 30%                | 30%              | 25%                    | 150°C/150°C          |
3. Results and analysis

3.1. BP neural network anti-real experiment

On the basis of the orthogonal experiment, the BP neural network is used for modeling, and the prediction model is established, and the simulation analysis is performed for further verification experiments to predict the simulation data of similar products.

The forecast data is analysed by the BP neural network program in DPS software.

The results and analysis of the orthogonal experiment are shown in Table 3.

| factor No. | A | B | C | D | E Sensory evaluation | F Hardness/N | G Chew /mJ |
|-----------|---|---|---|---|---------------------|-------------|----------|
| 1         | 1 | 1 | 1 | 1 | 75.6                | 36.23       | 2.81     |
| 2         | 1 | 2 | 2 | 2 | 79.2                | 35.20       | 1.88     |
| 3         | 1 | 3 | 3 | 3 | 82.5                | 20.57       | 2.48     |
| 4         | 2 | 1 | 2 | 3 | 81.8                | 16.70       | 3.01     |
| 5         | 2 | 2 | 3 | 1 | 72.9                | 65.20       | 1.94     |
| 6         | 2 | 3 | 1 | 2 | 85.6                | 17.23       | 1.57     |
| 7         | 3 | 1 | 3 | 2 | 87.5                | 14.53       | 2.01     |
| 8         | 3 | 2 | 1 | 3 | 77.5                | 34.57       | 1.81     |
| 9         | 3 | 3 | 2 | 1 | 83.9                | 22.10       | 1.82     |

According to the sensory scores, hardness and chewiness of the biscuits, the R (Range) size comparison found that the influence of the four factors on the sea rice weight loss biscuits is B>D>A>C, that is, the amount of powdered sugar added to the biscuit, that the biggest influence is the baking temperature and the amount of low-gluten flour added. Through the comparison of the sensory score, hardness and chewiness of the biscuits and the K value, it can be found that the better formulas of sea rice biscuits are A3B1C3D2, A3B3C2D2, A2B3C1D2, A3B2C1D2. In order to determine the best formula for sea rice weight-loss biscuits.
Table 4. Comparison of original data and BP modeling data

| No. | Sensory evaluation | Prediction | Hardness /N | Prediction | Chew /mJ | Prediction |
|-----|-------------------|------------|-------------|------------|----------|------------|
| 1   | 75.6              | 75.5805    | 36.23       | 36.5594    | 2.81     | 2.8077     |
| 2   | 79.2              | 79.1689    | 35.20       | 35.2056    | 1.88     | 1.8847     |
| 3   | 82.5              | 82.4932    | 20.57       | 20.7660    | 2.48     | 2.4781     |
| 4   | 81.8              | 81.8090    | 16.70       | 17.1050    | 3.01     | 3.0017     |
| 5   | 72.9              | 73.2174    | 65.20       | 64.8278    | 1.94     | 1.9402     |
| 6   | 85.6              | 85.6114    | 17.23       | 17.7330    | 1.57     | 1.5927     |
| 7   | 87.5              | 87.2578    | 14.53       | 15.2001    | 2.01     | 2.0102     |
| 8   | 77.5              | 77.4988    | 34.57       | 35.3775    | 1.81     | 1.8100     |
| 9   | 83.9              | 83.8990    | 22.10       | 22.3747    | 1.82     | 1.8171     |

Figure 1. Sensory evaluation factor response curve

Table 5. The weight matrix of each node in the first hidden layer of the Sensory evaluation

|       | 0.1282 | 3.1099 | -1.8493 | 0.7479 |
|-------|--------|--------|---------|--------|
| -3.0348 | 1.1593 | -1.6537 | -1.2130 | -1.1156 | -1.2296 |
| 3.1551 | -3.2206 | -3.2356 | -0.6774 | -3.2376 |
| -4.4139 | 2.8254 | 4.6799 | -1.1043 | 2.0807 |
Table 6. Sensory evaluation training sample prediction data

| No.  | Sensory evaluation | Residual  |
|------|--------------------|-----------|
| Training1 | 75.5805 | -0.0195 |
| Training2 | 79.1689 | -0.0311 |
| Training3 | 82.4932 | -0.0068 |
| Training4 | 81.8090 | 0.0090 |
| Training5 | 73.2174 | 0.3174 |
| Training6 | 85.6114 | 0.0114 |
| Training7 | 87.2578 | -0.2422 |
| Training8 | 77.4988 | -0.0012 |
| Training9 | 83.8990 | -0.0010 |

Mean square error (MSE) \(0.0179\)
Residual standard deviation (RSE) \(0.1419\)
Mean absolute deviation (MAD) \(0.0711\)

Figure 2. Hardness factor response curve

Table 7. Weight matrix of each node in the first hidden layer of hardness

|       | -1.4423 | -0.2360 | 2.5428 | -3.1462 |
|-------|---------|---------|--------|---------|
| 3.0397|         |         |        |         |
| -0.4775| 1.5586 | 3.7572 | -0.2899 | 0.5833 |
| -3.1159| 3.5006 | 0.9470 | -2.3765 | 3.2788 |
| 4.4635| -0.8065 | 2.3311 | 3.6113 | -4.7248 |
Table 8. Hardness training sample prediction data

| No.    | Hardness | Residual |
|--------|----------|----------|
| Training1 | 36.5594  | 0.3294   |
| Training2 | 35.2056  | 0.0056   |
| Training3 | 20.7660  | 0.1960   |
| Training4 | 17.1050  | 0.4050   |
| Training5 | 64.8278  | -0.3722  |
| Training6 | 17.7730  | 0.5430   |
| Training7 | 15.2001  | 0.6701   |
| Training8 | 35.3775  | 0.8075   |
| Training9 | 22.3747  | 0.2747   |

Mean square error (MSE) 0.2134
Residual standard deviation (RSE) 0.4900
Mean absolute deviation (MAD) 0.4004

Figure 3. Response curve of chewiness factor

Table 9. The weight matrix of each node in the first hidden layer of chewiness

|       | -0.9117 | -0.4278 | 0.9312 | 0.0872 | 3.2687 |
|-------|---------|---------|--------|--------|--------|
|       | 0.0805  | -1.4143 | -0.3694 | -7.3031 | 1.1840 |
|       | -1.9788 | 0.2385  | 2.0635  | -4.0265 | -0.7383 |
|       | 0.5765  | -0.1646 | -0.3775 | 2.2478  | -1.6790 |
Table 10. Chewy training sample prediction data

| No.     | Chewy     | Residual |
|---------|-----------|----------|
| Training1 | 2.8077    | -0.0023  |
| Training2 | 1.8847    | 0.0047   |
| Training3 | 2.4781    | -0.0019  |
| Training4 | 3.0017    | -0.0083  |
| Training5 | 1.9402    | 0.0002   |
| Training6 | 1.5927    | 0.0227   |
| Training7 | 2.0102    | 0.0002   |
| Training8 | 1.8100    | 0.0000   |
| Training9 | 1.8171    | -0.0029  |

Mean square error (MSE) 0.0001
Residual standard deviation (RSE) 0.0088
Mean absolute deviation (MAD) 0.0048

3.2. Result analysis
Comparing the results obtained by the model with the orthogonal optimal data, the two sets of experimental errors are small, and the BP experimental results have good predictability. In the best combination, A2B3C1D2, the indicators after verification were that: sensory 87.9, hardness 15.34, chewiness 1.52. The predicted value is 87.2578 for sensory, 15.2001 for hardness, and 2.0102 for chewiness. The difference between the three predicted values and the actual index is small, respectively -0.0073%, -0.0091%, and 0.3225%. The difference in chewiness is slightly larger, but also less than 0.5%. This influence is estimated to come from individual differences in taste, and the overall prediction effect is good.

4. Conclusion
This experiment uses artificial neural network combined with orthogonal experimental data to fully mine the information of the experimental data and establish a neural network model. Through the simulation model to evaluate and predict the sensory evaluation index data of the product, and compared with the actual data, the two sets of test errors are small, the BP test results are highly feasible, cost-saving, and energy consumption. It shows that the new model prediction scheme and data processing method proposed by artificial neural network prediction is feasible. This optimization method provides a new way for product formulation optimization and sensory evaluation simulation design.

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