Study on Making Formulation of Jujube Dietary Fiber Tableware

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Abstract. Objective: To develop jujube dietary fiber tableware and optimize the best formula for jujube dietary fiber tableware. Methods: The tableware samples were made from the raw materials of jujube dietary fiber tableware according to different formulations, and the properties of anti-impact, leakage time, falling resistance, color and smell were evaluated, and the response surface method was used to establish a model for analysis and optimization, and the best formula was finally determined. Results: The results showed that the best formula of jujube dietary fiber tableware was jujube dietary fiber 4.1g, starch 5.0g, white granulated sugar 5.0g, gelatin 0.1g, carrageenan 0.1g, glycerol 1.0mL, water 12.0mL, fermentation time 23.0min. Conclusion: Through the best formula, the color and hardness of jujube dietary fiber tableware are similar to those of normal wooden tableware, and the jujube dietary fiber tableware is beautiful and practical.

1. Introduction
Jujube is the dried and mature fruit of Ziziphus jujuba Mill. (Rhamnaceae) [1]. There are a lot of jujube lost and wasted due to natural disasters and unreasonable utilization every year, so it is of great significance to carry out research on deep processing and comprehensive utilization of jujube [2]. In this study, jujube residue was used as raw materials to extract jujube dietary fiber, thus a kind of tableware rich in jujube dietary fiber was developed, which provided a reference for the development of degradable and pollution-free green tableware.

2. Methods and results
2.1. Preparation of jujube dietary fiber
Self made in laboratory: Drying of jujube residue→Crushing→Passing sieve No. seven→Weighing of pre prepared jujube residue→Adding hydrochloric acid at 45°C water bath temperature and mixing with water→filtering dregs→washing→drying and weighing (insoluble dietary fiber) [3].
2.2. Preparation of tableware of jujube dietary fiber
Prepare different jujube dietary fiber tableware according to the designed prescription [4].

2.3. Performance test [5]
Through the performance test, the performance of jujube dietary fiber tableware samples made under different raw material ratio was evaluated. The performance evaluation standard are shown in Table 1.

Table 1. Performance evaluation standard.

| Standard                  | Evaluation standard                                                                 |
|---------------------------|--------------------------------------------------------------------------------------|
| Anti-impact (20 scores)   | No change, 15–20; There are cracks, 8–14; Splintering, 0–7                         |
| leakage time (20 scores)  | ≥60min, 15–20; 30–45min, 10–14; 0–30min, 0–9                                     |
| Falling resistance (20 scores) | No change, 15–20; There is a crack but not a fracture, 10–14; Fracture, 0–9 |
| Color (20 scores)         | Brown, 15–20; Black brown, 8–14; Gray brown, 0–7                                |
| Smell (20 scores)         | It has the smell of jujube, 15–20; Basically no smell of jujube, 8–14; There is a roasting smell, 0–7 |

2.4. Result analysis

2.4.1. Single factor experimental analysis.
(1) Effect of different addition ratio of jujube dietary fiber to starch on tableware
The different addition ratio of jujube dietary fiber and starch has great influence on jujube dietary fiber tableware. Dietary fiber has better water retention. Adding dietary fiber to the dough can increase the water absorption of the dough, adjust the extensibility and flexibility of the dough, increase the plasticity of the dough and improve the product quality [6]. In the preliminary experiment, it was found that when the ratio of jujube dietary fiber and starch was between 0.6:1 and 1:1, the dough had better ductility and plasticity, which was beneficial to sample preparation.

(2) Effect of water quantity on tableware
In the early pre experiment, it was found that adding too much water would make the dough difficult to form, and the hardness of the sample made was not enough and easy to deform; Adding too little water would make the dough viscosity was not enough, the ductility and flexibility was too low, and the sample made was slightly rough. When the amount of water added was between 10-16mL, the dough had good ductility and flexibility, which was beneficial to sample preparation.

(3) Effect of different fermentation time on tableware
In the previous pre-experiment, it was found that if the fermentation time was too short, the dough would be too sticky and the hardness of the sample would be insufficient; Too long fermentation time would reduce the malleability of the dough, which was not conducive to forming. When the fermentation time was between 20–30min, the water content of the dough was more suitable, and the dough was sticky, which was beneficial to the preparation of the sample.

2.4.2. Experimental analysis of response surface.
(1) Experimental design
Through the single factor experiment, it was known that jujube dietary fiber addition, the amount of water added and fermentation time had great effect on the production technology of tableware. Design-Export 8.0.6 was used in this experiment. The Box-Behnken program in the software carries on the experimental design of three factors and three levels. The experimental factors and levels were shown in Table 2.
Table 2. Test factors and level.

| Levels | A / Jujube Dietary fiber addition /g | B / The amount of water added /mL | C / Fermentation time / min |
|--------|-------------------------------------|----------------------------------|-----------------------------|
| -1     | 3                                   | 10                               | 20                          |
| 0      | 4                                   | 13                               | 25                          |
| 1      | 5                                   | 16                               | 30                          |

(2) Evaluation standard

The samples of jujube dietary fiber tableware were scored according to the performance evaluation standard in Table 1.

(3) Response surface test results

The formulation of tableware samples was optimized by Design Expert V 8.0.6 software. The test scheme and results are shown in Table 3.

Table 3. Test design and results.

| Std | Run | A / g | B / mL | C / min | Response |
|-----|-----|-------|--------|---------|----------|
| 8   | 1   | 5.00  | 13.00  | 30.00   | 71       |
| 7   | 2   | 3.00  | 13.00  | 30.00   | 70       |
| 2   | 3   | 5.00  | 10.00  | 25.00   | 75       |
| 13  | 4   | 4.00  | 13.00  | 25.00   | 80       |
| 12  | 5   | 4.00  | 16.00  | 30.00   | 74       |
| 17  | 6   | 4.00  | 13.00  | 25.00   | 82       |
| 9   | 7   | 4.00  | 10.00  | 20.00   | 79       |
| 1   | 8   | 3.00  | 10.00  | 25.00   | 69       |
| 11  | 9   | 4.00  | 10.00  | 30.00   | 54       |
| 14  | 10  | 4.00  | 13.00  | 25.00   | 84       |
| 10  | 11  | 4.00  | 16.00  | 20.00   | 56       |
| 5   | 12  | 3.00  | 13.00  | 20.00   | 74       |
| 4   | 13  | 5.00  | 16.00  | 25.00   | 63       |
| 6   | 14  | 5.00  | 13.00  | 20.00   | 72       |
| 15  | 15  | 4.00  | 13.00  | 25.00   | 82       |
| 3   | 16  | 3.00  | 16.00  | 25.00   | 69       |
| 16  | 17  | 4.00  | 13.00  | 25.00   | 80       |

Final Equation in Terms of Coded Factors:

\[ Y = +81.60 - 0.12A - 1.87B - 1.50C - 3.00AB + 0.75AC + 10.75BC - 3.30A^2 - 9.30B^2 - 6.55C^2 \]

Through the analysis of variance of the regression equation, the results are shown in Table 4.
Table 4. Analysis of variance of regression equation.

| Source     | Sum of squares | Degree of freedom | Mean square | F      | P         | Significant |
|------------|----------------|-------------------|-------------|--------|-----------|-------------|
| Model      | 1194.17        | 9                 | 132.69      | 42.31  | < 0.0001  | Significant |
| A          | 0.13           | 1                 | 0.13        | 0.040  | 0.8474    |             |
| B          | 28.13          | 1                 | 28.13       | 8.97   | 0.0201    | *           |
| C          | 18.00          | 1                 | 18.00       | 5.74   | 0.0478    | *           |
| AB         | 36.00          | 1                 | 36.00       | 11.48  | 0.0116    | *           |
| AC         | 2.25           | 1                 | 2.25        | 0.72   | 0.4250    |             |
| BC         | 462.25         | 1                 | 462.25      | 147.41 | < 0.0001  | **          |
| A^2        | 45.85          | 1                 | 45.85       | 14.62  | 0.0065    | **          |
| B^2        | 364.17         | 1                 | 364.17      | 116.14 | < 0.0001  | **          |
| C^2        | 180.64         | 1                 | 180.64      | 57.61  | 0.0001    | **          |
| Residual error | 21.95       | 7                 | 3.14        |        |           |             |
| Lack of Fit | 10.75         | 3                 | 3.58        | 1.28   | 0.3949    | not significant |
| Pure error  | 11.20          | 4                 | 2.80        |        |           |             |
| Cor Total   | 1216.12        | 16                |             |        |           |             |
| R-Squared   | 0.9820         |                   |             |        |           |             |
| C.V.%       | 2.44           |                   |             |        |           |             |
| Adeq Precision | 19.862     |                   |             |        |           |             |

Note: "***" (P<0.05), Significant; "**" (P<0.01), Extremely significant

It can be seen from table 4 that the P value of the model is (< 0.0001) < 0.05, indicating that the model is significant and the fitting accuracy is good, so the approximate model of the response surface can be used for optimal design, and the P value of lack of fit is 0.3949 > 0.05, that is, it is not significant, indicating that the approximate model fits well in the whole regression area under study; R^2 = 0.9820, indicating that the model fits well; C.V. = 2.44% < 10%, indicating that the reliability and accuracy of the test are both high. Adeq precision, i.e. accuracy = 19.862 > 4, indicates that the model is reasonable [7].

(4) Factor interaction analysis

![Figure 1. Contour map and response surface map of jujube dietary fiber addition and the amount of water added to the score of tableware samples.](image-url)
From Fig.1, Fig.2, Fig.3, we can see that the maximum range of jujube dietary fiber addition, the amount of water added and fermentation time.

3. Verification test
Through the optimization analysis by using Design Expert V 8.0.6 software, the best formula of jujube dietary fiber tableware was obtained as follows: jujube dietary fiber 4.09g, starch 5.0g, white granulated sugar 5.0g, gelatin 0.1g, carrageenan 0.1g, glycerol 1.0mL, water 11.98mL, fermentation time 23.06min. Considering the maneuverability of tableware sample production, the dietary fiber of jujube was changed to 4.1g, the amount of water added was changed to 12.0mL, and the fermentation time was changed to 23.00min. According to the formula, it was verified by repeated experiments for three times under the same conditions that the tableware sample had good hardness and beautiful color. Therefore, it can be considered that the selection of the test model is reasonable and the test results are ideal.

4. Conclusion
Through the single factor test and response surface method design test, and scored from the aspects of impact resistance, leakage time, fall resistance, color and smell, the best formula of jujube dietary fiber tableware was as follows: jujube dietary fiber 4.1g, starch 5.0g, white granulated sugar 5.0g, gelatin 0.1g, carrageenan 0.1g, glycerol 1.0mL, water 12.0mL, fermentation time 23.0min. Under this formula, the color and hardness of tableware are similar to those of wooden tableware. At present, the state...
advocates the construction of ecological civilization, and the emergence of environmentally friendly tableware meets the needs of the people and is conducive to the construction of ecological civilization. Although jujube dietary fiber tableware needs to be improved in terms of hardness, preservation time and water resistance, it is believed that it will have a broad market prospect through the continuous improvement of researchers.

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