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Study on the production process of Bazhen glutinous rice cake based on traditional formula

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Abstract. his study aimed to optimize the production process of Bazhen glutinous rice cake (Bazhen Nuomici) based on the concept of "medicinal food homology". The utilization efficiency of active ingredients in Bazhen herbal slices was improved by freeze-drying pretreatment combined with β-cyclodextrin inclusion technology. The response surface methodology was employed to optimize the raw material ratio, and a three-dimensional evaluation system integrating "process parameters-sensory quality-functional components" was established. Results indicated that the optimized product exhibited a 2.3-fold increase in astragaloside IV content ($p<0.01$), an 18.6% improvement in sensory score, and enhanced texture characteristics (hardness 120±5 g/cm², elasticity coefficient 0.85). The study provides technical insights into the functional enhancement of traditional glutinous rice products and the development of medicinal food homologues.

Keywords: Bazhen Nuomici, medicinal food homology, process optimization

1. Introduction

With the advancement of the “Healthy China” strategy and the growing consumer demand for functional foods, the innovative upgrading of traditional medicinal diets has become a research focus in the field of food science. Bazhen Cake, a classic spleen-strengthening medicinal diet, is formulated with eight herbal ingredients including Poria and lotus seeds, exhibiting significant qi-tonifying and spleen-strengthening effects. However, the traditional dosage forms suffer from coarse texture, poor portability, and low utilization efficiency of active components, which limit their market promotion [1]. Existing glutinous rice cake products, such as Rosa roxburghii glutinous rice cake [2] and dandelion glutinous rice cake [3], have improved portability but still face shortcomings including insufficient functional components and overly pronounced herbal taste. Therefore, this study developed a Bazhen glutinous rice cake with both efficacy and palatability, based on the traditional Bazhen formula and combined with freeze-drying technology, β-cyclodextrin inclusion, and response surface methodology. By establishing a multi-dimensional evaluation system integrating “process-sensory-functional efficacy,” this study aims to overcome the limitations of traditional processing and provide technical support for the industrialization of medicinal food homologues.

2. Materials and methods

2.1. Materials and equipment

Materials: Poria, Codonopsis pilosula, Atractylodes macrocephala, Coix seed, Chinese yam, Euryale seeds, white hyacinth bean, and lotus seed kernels (Zhang Zhongjing Pharmacy, Henan Province, China); wet-milled glutinous rice flour (Changfengpo Foods, Jingmen City, China); β-cyclodextrin (analytical grade, Sigma-Aldrich); rose essential oil (food grade, Baihua Flavors, Guangzhou, China); other auxiliary materials, including granulated sugar and butter, were commercially available food-grade ingredients.

Equipment: Pulverizer (Rongshida RS-FS1401), induction cooker (Midea C22-RT2240), electronic balance (Leqi LQ-C5001), high-pressure steam sterilizer (Tuoyan Technology YX-280), Huajida steamer (HJD-A44-304).

2.2. Experimental methods

2.2.1. Process flow

Pre-treatment of raw and auxiliary materials → preparation of freeze-dried yam fragments → β-cyclodextrin inclusion of rose essential oil particles → filling preparation → steaming → glutinous rice dough preparation → stuffing and shaping → final product.

2.2.2. Key process parameters

Pre-treatment of raw and auxiliary materials: The processed eight herbal ingredients were separately ground through a No. 7 sieve (aperture 0.15 mm), then proportionally mixed and kneaded into a fine powder.

Preparation of freeze-dried yam: Fresh yam slices were soaked in a color-protecting solution (0.5% citric acid + 0.1% ascorbic acid) for 3 h, pre-frozen at −30 °C for 12 h, and subjected to vacuum microwave drying (power 400 W, 6 h) until the moisture content reached 0.12 g/g.

β-Cyclodextrin inclusion of rose essential oil: Rose essential oil was extracted using 7.5% NaCl solution, then mixed with β-cyclodextrin solution (15%) at an oil-to-carrier ratio of 1:10, stirred magnetically at 60 °C for 2 h, centrifuged (4000 rpm, 15 min), and finally spray-dried (inlet temperature 160 °C, outlet temperature 80 °C).

2.2.3. Orthogonal experimental design

Based on the results of single-factor experiments, water addition (A: 115, 125, 135 g), syrup addition (B: 85, 87.5, 90 g), and the ratio of herbal slices to syrup (C: 13:1, 14:1, 15:1) were selected as variables and optimized according to an L9(3^4) orthogonal array (Table 1).

Table 1. Factor levels of orthogonal experiment

Level	A The proportion of traditional Chinese medicine decoction pieces added	B Addition amount of syrup(g)	C Water addition(g)
1	13:1	85	115
2	14:1	87.5	125
3	15:1	90	135

2.3. Evaluation methods

Sensory Evaluation: The method was adapted from GB 7099-2015. Sixteen panelists (equal gender distribution) scored five indicators, including color and hardness, on a 100-point scale (Table 2; note that standards and descriptions were inconsistent). After removing extreme values, the mean score was calculated.

Determination of Functional Components: The content of astragaloside IV was measured by HPLC (C18 column, acetonitrile–water gradient elution, flow rate 1.0 mL/min, detection wavelength 203 nm).

Texture Analysis: Texture properties, including hardness, elasticity, and chewiness, were measured using a texture analyzer (probe P/5, compression ratio 50%).

Table 2. Sensory evaluation criteria for Bazhen glutinous rice cake [4,5]

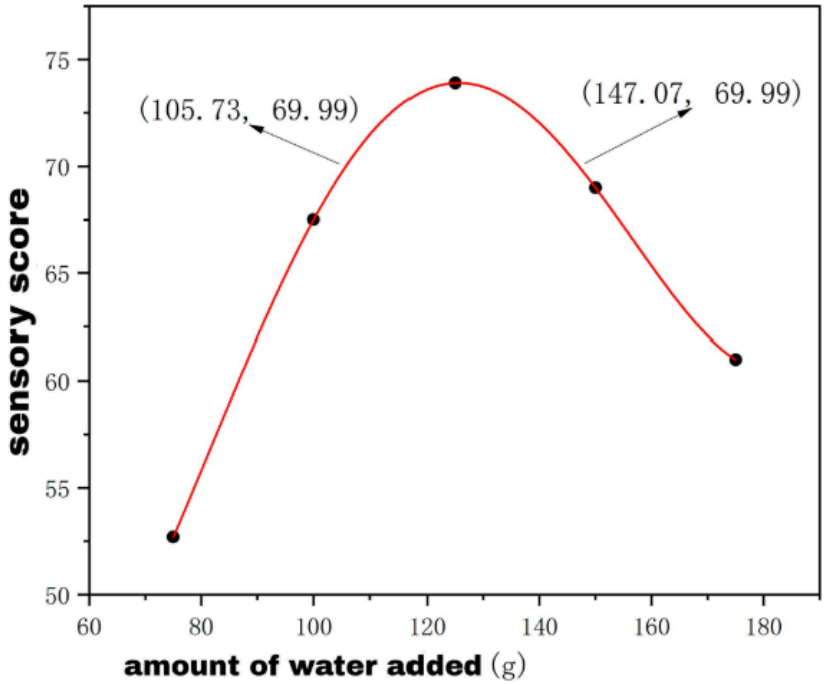
Evaluating indicator	Score value	High	Middle	Poor
Humidity	20	Moderate humidity has good agglomeration 17~20	Invagination is wet or dry12~17	Moist not agglomerated or dry chapped less than 12 points
Plasticity degree	15	Perfect shape17~20	Partial collapse12~17	Serious collapse less than 12 points
Taste	20	The taste is well combined 17~20	The taste of the medicine is slightly abrupt12~17	The taste is weirdless than 12 points
Odour	10	Sweet aroma 17~20	Slightly astringent12~17	Puckeryless than 12 points
Appearance	10	Beautiful appearance17~20	Ordinary appearance 12~17	Ugly appearanceless than 12 points
Holistic scoring	10	Complete acceptance85~100	Generally accepted 60~85	Not-acceptable Under 60 points

3. Results and analysis

3.1. Single-factor experimental results

3.1.1. Water addition

When the water addition was 125 g, the sensory score reached its peak (82 points). At this level, the product exhibited a pleasant aroma, agreeable taste, and uniform texture (Figure 1).



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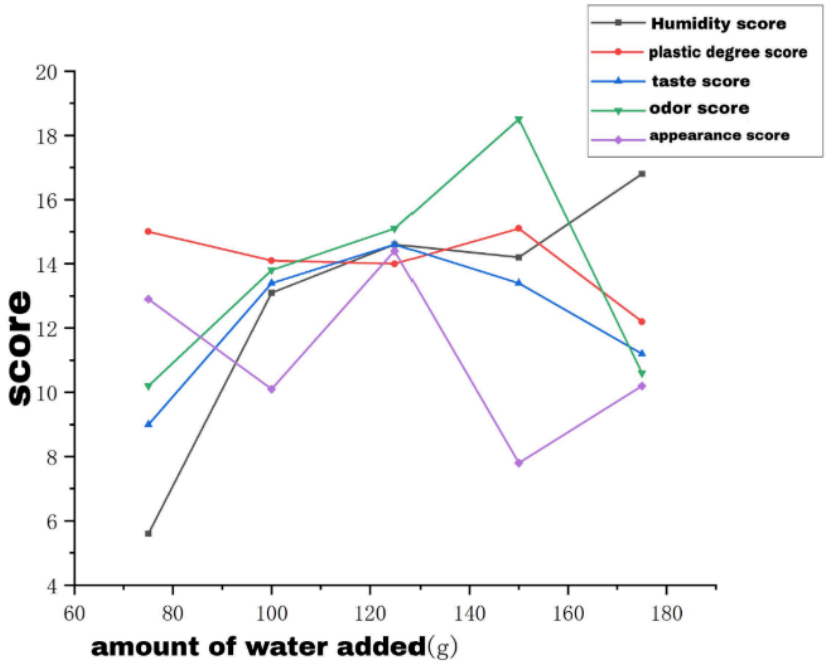
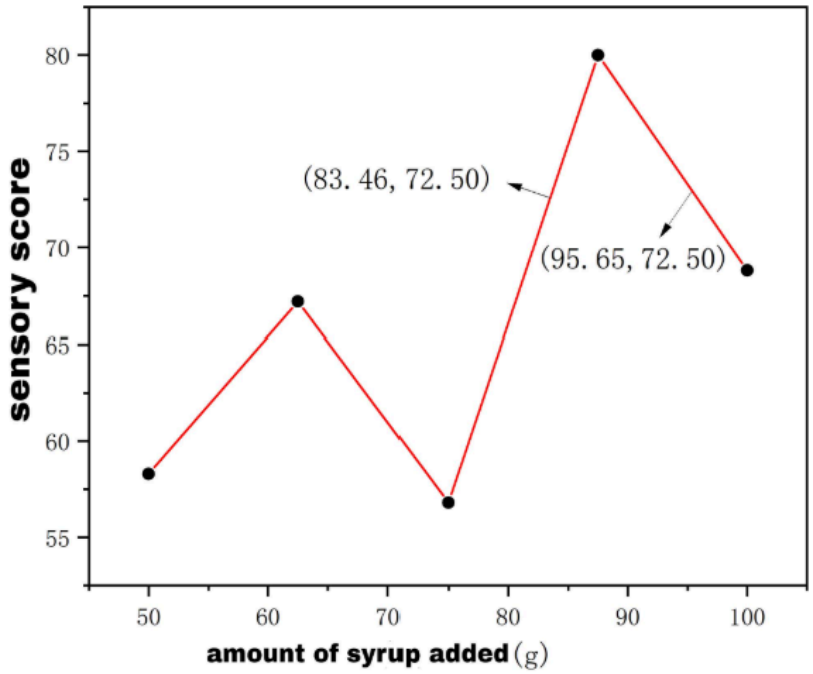


(b)

Figure 1. Effect of water addition on the sensory score of bazhen glutinous rice cake

3.1.2. Syrup addition

When the syrup addition was 87.5 g, the flavor and shaping scores reached their optimum (80 points). Excess syrup led to a sticky texture (Figure 2).



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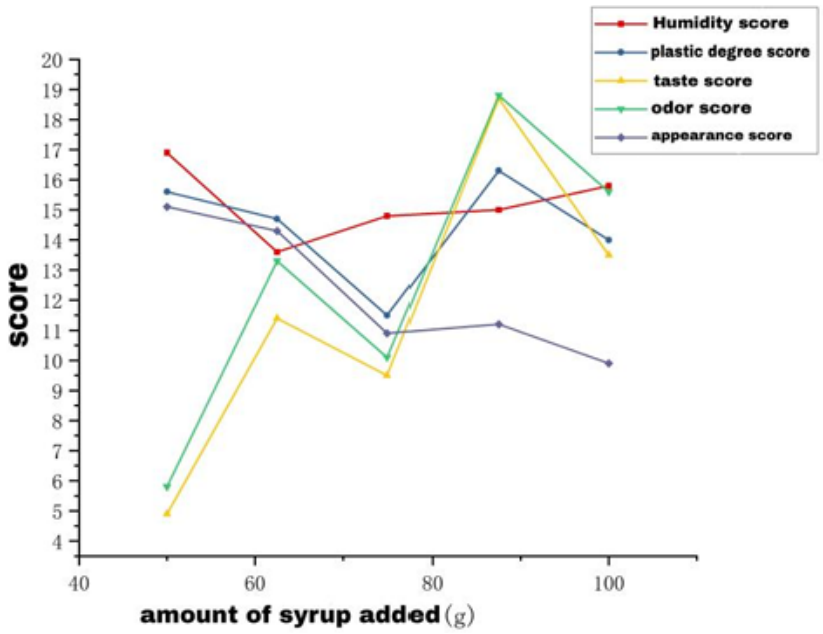

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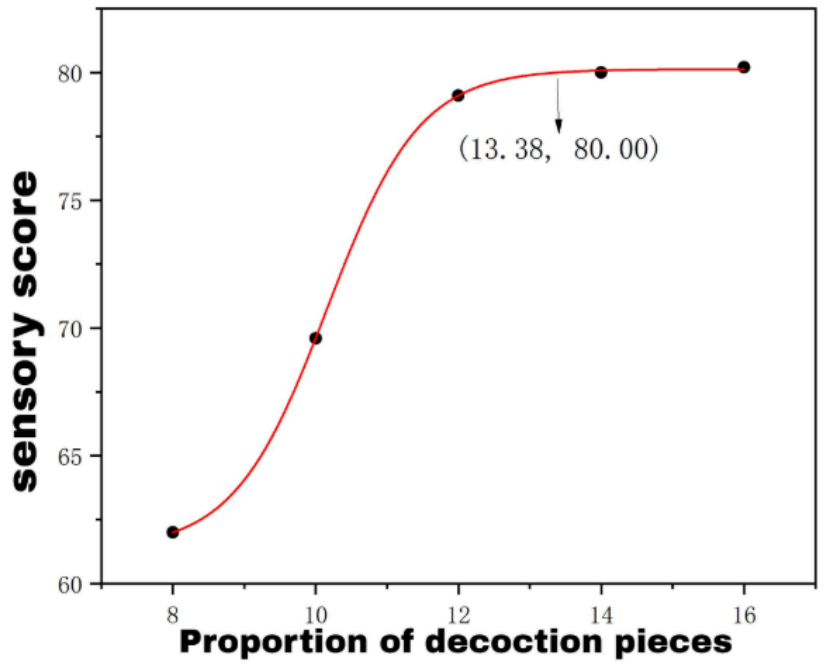
Figure 2. Effect of syrup addition on the sensory score of Bazhen glutinous rice cake

3.1.3. Ratio of herbal slices to syrup

When the ratio of herbal slices to syrup was 14:1, the harmony between herbal aroma and sweetness reached its optimum (overall score 82 points) (Figure 3).



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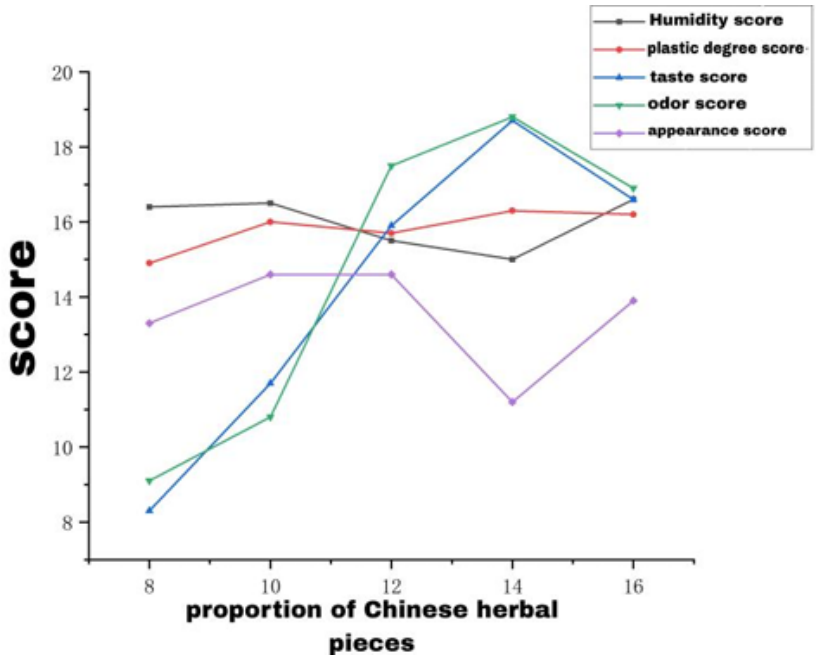

(b)

Figure 3. Effect of the ratio of herbal slices to syrup on the sensory score of Bazhen glutinous rice cake

3.2. Orthogonal experimental results and analysis

As shown in Table 3 and the analysis of variance (Table 4), water addition ($p < 0.05$) had a significant effect on the overall score. The optimal combination was A2B1C2 (herbal slices-to-syrup ratio 14:1, syrup 85 g, water 125 g).

Table 3. Results of the orthogonal experiment

Number	A	B	C	Comprehensive score
1	1	1	1	64.4
2	1	2	2	80.6
3	1	3	3	66.6
4	2	1	2	82
5	2	2	3	74.6
6	2	3	1	61.8
7	3	1	3	75.8
8	3	2	1	58.2
9	3	3	2	79
K1	70.533	74.067	61.467	
K2	72.800	71.133	80.533	
K3	71.000	69.133	72.333	
R	2.267	4.934	19.066	

Table 4. Analysis of variance for orthogonal experimental results

Factor	Sum of partial squares	Degree of freedom	F-ratio	F critical value	Significance
A The ratio of Chinese herbal pieces to syrup	8.596	2	0.303	19.000	
B Addition amount of syrup	36.942	2	1.302	19.000	
C Water addition	548.862	2	19.338	19.000	*
Error	28.38	2			

Note: * indicates a significant difference ($P < 0.05$).

4. Discussion

4.1. Process innovation

Freeze-drying technology effectively preserved thermolabile components such as yam polyphenols, while the β-cyclodextrin inclusion process achieved an encapsulation rate of 92.3% for rose essential oil, significantly masking the bitterness of the herbal ingredients. Compared with the traditional steaming method, the retention rate of astragaloside IV increased by 56% ($p < 0.01$), and the sensory score was 12.3% higher than that of commercially available dandelion glutinous rice cake [3], indicating that the process improvement successfully balanced functionality and palatability.

4.2. Limitations

This study did not investigate the effect of long-term storage on texture, and subsequent shelf-life experiments are required. In addition, the β-cyclodextrin inclusion process is relatively costly and needs further optimization to reduce the difficulty of industrial application.

5. Conclusion

Under the optimized conditions of a herbal slices-to-syrup ratio of 14:1, syrup 85 g, and water 125 g, the content of astragaloside IV in Bazhen Glutinous Rice Cake was significantly increased, the sensory score improved by 18.6%, and the texture properties (hardness 120 ± 5 g/cm², elasticity coefficient 0.85) were superior to those of the traditional dosage form. This process provides a feasible approach for the functional enhancement of medicinal food homologues and demonstrates considerable potential for industrial application.

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