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# Orthogonal Optimization Design for the Preparation of Mesona Jelly

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**Abstract: This study focuses on the optimization of preparation methods and ingredient ratios for a medicinal and edible *Mesona chinensis Benth.* Jelly. Using sensory evaluation scores as indicators, single-factor analysis was conducted to determine the preparation methods and optimal ingredient ratios for successful jelly formation. The optimized preparation method, based on sensory evaluation scores, is as follows: 50g of dried *Mesona chinensis Benth.*, 5 kilogram of water, and 14g of alkali. The mixture undergoes two rounds of boiling and filtering, with the plant juice being squeezed out and combined with the filtrate. The combined filtrate is then brought to a boil again and maintained at a gentle simmer while a pre-prepared edible canna flour solution is slowly added in a clockwise direction. The ratio of dried *Mesona chinensis Benth.* to edible canna flour is 1:1.3.**

**Keywords: *Mesona chinensis Benth* Jelly; Preparation; Orthogonal Design**

## 1. Introduction

*Mesona chinensis Benth.*, also known as *Mesora chinensis*, Platostoma palustre, or black tofu grass, is a perennial herbaceous plant belonging to the genus *Mesona Bl.* of the *Labiatae* family [1,2]. There are 8-10 species of *Mesona* worldwide, with 3 species found in China. China is the world's leading producer of *Mesona chinensis Benth.,* primarily cultivated in the provinces (regions) of Fujian, Guangdong, Guangxi, Zhejiang, Jiangxi, and Yunnan, with Fujian and Guangdong provinces having the largest cultivation areas. Currently, Wuping County in Longyan, Fujian Province, meets approximately 80% of the national demand for *Mesona chinensis Benth.*, making it the primary production area for *Mesona chinensis Benth.* in China. In Traditional Chinese Medicine, *Mesona chinensis Benth.* is commonly used to treat various conditions including heat stroke, childhood impetigo, erysipelas affecting internal organs, common cold, hypertension, jaundice, kidney disease, diabetes, and joint and muscle pain [3]. Modern research indicates that Mesona chinensis Benth contains various compounds including mesona gum (polysaccharides), polyphenols, flavonoids, polysaccharides, terpenes, and volatile oils, as well as triterpenes and other compounds [4]. It also demonstrates antioxidant, anti-hypoxic, antihypertensive, hypoglycemic, and lipid-lowering properties [3,4]. Through a series of experiments, Huang Jiajin discovered that crude extracts of Mesona chinensis Benth, total polyphenols, and total polysaccharides demonstrated therapeutic effects on type II diabetic mice to varying degrees. These compounds significantly improved various indicators in mice, including fasting blood glucose, body weight, oral glucose tolerance, and pancreatic and liver damage markers [4]. Yang Min, Xu Zhengping, and others from Zhejiang University have pharmacologically demonstrated that the water extract of *Mesona chinensis Benth.* provides certain protective effects against kidney damage in diabetic patients [5]. *Mesona chinensis Benth.* jelly can be further developed into functional health foods with special properties [6,7].

Possibly due to changes in soil quality, in recent years, *Mesona chinensis Benth.* jelly prepared using traditional methods (commonly known as Grass jelly) has shown variations in jelly formation. The gelation quality varies between different production areas and even within the same production area. There are no clear standards for the amount of herb, edible alkali, and the type and quantity of starch to be used, resulting in unstable jelly formation -

sometimes too firm and sometimes too soft. Currently, *Mesona chinensis Benth.* jelly production often involves excessive addition of gelling agents to increase the gelation rate. This study selected dried *Mesona chinensis Benth.* with good gelation properties from China's main production area in Wuping County, Longyan City, Fujian Province. Using single-factor analysis and orthogonal experimental design, combined with traditional production methods, we optimized the preparation process and determined the optimal ratios of dried *Mesona chinensis Benth.*, edible alkali, and starch. This work establishes a foundation for the further development of healthy *Mesona chinensis Benth.* products. The experiments, combined with traditional preparation methods of Mesona chinensis Benth jelly, optimize the production process for Mesona chinensis Benth jelly, making it feasible for large-scale production of canned Mesona chinensis Benth jelly or jelly products [8], which has strong practical significance.

## 2. Main Text

### 2.1 Equipment and Materials

Instruments:
Induction Cooker (Midea Group Co., Ltd., Model: C22-RT22E0102), Pressure Cooker (Midea Group Co., Ltd., Model: YL50Q3-451), Electronic Balance (Shanghai Qinghai Instruments Co., Ltd., Model: YP601N)
Consumables and Reagents:
Dried *Mesona chinensis Benth.* (supplied by Longyan Wuping Lv lu Mesona Professional Cooperative, well-jellifying variety), Medical Gauze (commercially available), Food-grade Alkali (Jinjiang Guliangdao Food Co., Ltd., Batch: 20240103), Edible Canna Flour (roasted, supplied by Longyan Wuping Lv lu Mesona Professional Cooperative), Corn Starch (repackaged by Nanjing Ganzhiyuan Co., Ltd., Batch: 202312182), Tapioca Starch (repackaged by Nanjing Ganzhiyuan Co., Ltd., Batch: 202312192), Medical Gauze (commercially available)

### 2.2 Preparation of *Mesona chinensis Benth.* jelly:

According to traditional preparation methods, cleaned dried *Mesona chinensis Benth.* is combined with water and edible alkali in a large pot. After bringing to a boil, the mixture is maintained at a gentle simmer until more than half of the liquid has reduced. After two to three rounds of cooking, each batch is filtered through a 200-mesh or finer sieve, with maximum effort to squeeze out and incorporate the plant juice into the filtrate. The combined filtrate is brought to a boil again and maintained at a gentle simmer. Starch is mixed with a small amount of water and slowly added in a clockwise direction to the simmering *Mesona chinensis Benth.* liquid while stirring clockwise. Once completely dissolved, the heat is turned off, and the mixture is cooled to allow jellification. The traditional method requires large stoves, is time-consuming, and presents challenges in maintaining hygiene during the cooking and cooling processes [8].
The experiment compared the cooking effects between a pressure cooker and traditional stove methods. It was found that after soaking the dried *Mesona chinensis Benth.* for half an hour before pressure cooking, the processing time was significantly reduced, hygiene control was easier, cooking time was more controllable, and experimental reproducibility was higher. Therefore, combining the pressure cooker method with traditional cooking techniques, the production process for *Mesona chinensis Benth.* jelly was established, as shown in Figure 1.
Preparation of starch solution:

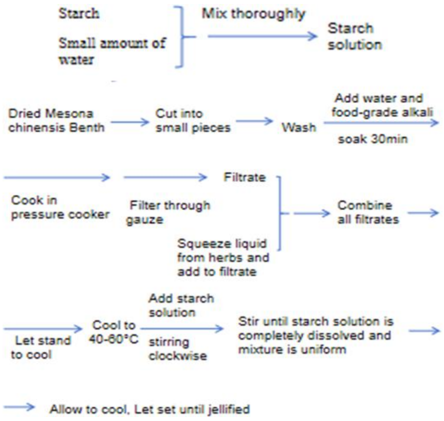


**Figure 1. Preparation Process of *Mesona chinensis Benth.* Jelly**

### 2.3 Single Factor Analysis and Results

Different quantities of dried *Mesona chinensis Benth.* (30g, 40g, 50g, 60g, and 70g) were selected, cut into smaller pieces, cleaned, and combined with 10 jin of water and 14g of alkali. After soaking for half an hour, the mixture was brought to a boil in a pressure cooker and maintained at a gentle simmer for 1 hour. The mixture was filtered through sterilized medical gauze (pre-washed and sun-dried), with the remaining plant juice squeezed out and combined with the filtrate. The filtrates from two rounds of cooking and the squeezed plant juice were combined, brought to a boil, and maintained at a gentle simmer. A pre-mixed starch solution was slowly added in a clockwise direction while stirring clockwise. After thorough mixing, the heat was turned off, and the jellification process was observed during cooling, followed by sensory evaluation. Using this single-factor evaluation method, each cooking batch included 5 kilogram of drinking water. With jelly formation sensory evaluation as the indicator, the study evaluated not only the quantity of dried *Mesona chinensis Benth.* but also the amount of edible alkali, different types of starch, various ratios of starch to dried *Mesona chinensis Benth.*, cooking duration, and the impact of the number of cooking cycles on jellification.

In each evaluation, all factors except the one being evaluated were kept at fixed values. Single-factor evaluation revealed optimal results with dried *Mesona chinensis Benth.* quantities between 40-60g, Food-grade alkali: 11-17g, Starch type: locally produced edible canna flour from Wuping County, Longyan, Ratio of edible canna flour to dried *Mesona chinensis Benth.*: 1:1.1-1:1.5. The optimal preparation method was determined to be: Soak dried *Mesona chinensis Benth.* in water with alkali for 30 minutes. The process involved two rounds of cooking, each maintaining a gentle simmer for 1 hour after reaching the boiling point. After each round of cooking, the liquid was squeezed from the plant material and combined with the filtered solution. The consolidated filtrate was heated to a gentle simmer before adding the starch solution (edible canna flour solution), which was stirred in clockwise direction until uniform. The heat was then turned off, and the mixture was allowed to cool and set. This method yielded the best sensory evaluation results.

## 2.4 Orthogonal Design and Results

Following the process optimized through single-factor experiments, an orthogonal experimental design was employed. Factor A was the weight of dried *Mesona chinensis Benth.* (g), factor B was the weight of food-grade alkali(g), and factor C was the ratio of dried *Mesona chinensis Benth.* to edible canna flour. The factor levels are shown in Table 1:

**Table 1. Factor Levels for Orthogonal Design**

| Factor | Level | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| A(g) | 40 | 50 | 60 |
| B(g) | 11 | 14 | 17 |
| C | 1:1.1 | 1:1.3 | 1:1.5 |

Following the factor levels in Table 1, experiments were conducted according to the L9($3^3$) orthogonal design table. Using sensory evaluation scores of the jellification as indicators, a *Mesona chinensis Benth.* jelly tasting activity was organized and sensory evaluation forms were collected. The results are shown in Tables 2 and 3.

**Table 2. Orthogonal Test Design and Results**

| Test number | A | B | C | Sensory score |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 2.58 |
| 2 | 1 | 2 | 2 | 9.32 |
| 3 | 1 | 3 | 3 | 5.47 |
| 4 | 2 | 1 | 2 | 6.43 |
| 5 | 2 | 2 | 3 | 9.01 |
| 6 | 2 | 3 | 1 | 6.43 |
| 7 | 3 | 1 | 3 | 3.86 |
| 8 | 3 | 2 | 1 | 7.39 |
| 9 | 3 | 3 | 2 | 7.07 |
| K1 | 17.370 | 12.870 | 16.400 | |
| K2 | 21.870 | 25.720 | 22.820 | |
| K3 | 18.320 | 18.970 | 18.340 | |
| k1 | 5.790 | 4.290 | 5.467 | |
| k2 | 7.290 | 8.573 | 7.607 | |
| k3 | 6.107 | 6.323 | 6.113 | |
| r | 1.500 | 4.283 | 2.140 | |
| Impact Order: B＞C＞A<br>Optimal combination: A2B2C2 | | | | |

Note: **indicates highly significant influence (P<0.01), *indicates significant influence (P<0.05)

**Table 3. Variance Analysis Results of Each Factor on Sensory Scores**

| Source of Variation | Sum of Squares | Degrees of Freedom | Mean Square | F-value | P-value | Significance |
|---|---|---|---|---|---|---|
| A | 3.751 | 2 | 1.875 | 24.080 | 0.040 | * |
| B | 27.544 | 2 | 13.772 | 176.840 | 0.006 | ** |
| C | 7.228 | 2 | 3.614 | 46.405 | 0.021 | * |
| Errore | 0.156 | 2 | 0.078 | | | |

According to the sensory evaluation scores shown in the tables, the optimal recipe for preparing *Mesona chinensis Benth.* jelly is: Combine traditional methods, the optimal ingredient formulation for *Mesona chinensis Benth.* jelly was determined to be: 50g of dried Mesona chinensis Benth, 5 kilogram of water, 14g of alkali, with a ratio of dried Mesona chinensis Benth to edible canna flour of 1:1.3.

Based on the aforementioned optimized preparation process and the optimization of raw material additions, the optimized small-scale production process for Mesona chinensis Benth jelly can be illustrated as shown in Figure 2:

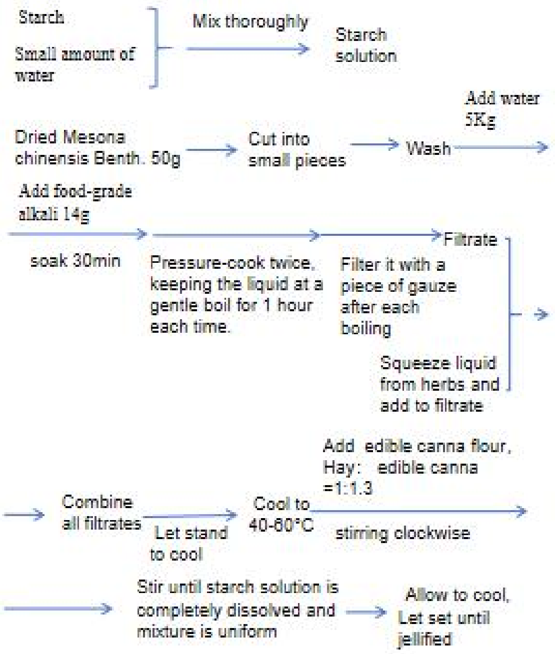


**Figure 2. Optimized Small-scale Production Process for Mesona chinensis Benth jelly**

## 3. Discussion of Results

Through single-factor and orthogonal experimental design, the optimal preparation method for *Mesona chinensis Benth.* jelly was determined as follows: 50g of dried *Mesona chinensis Benth.* is cut into pieces, cleaned, and combined with 5 kilogram of water and 14g of alkali. After soaking for half an hour, the mixture undergoes two rounds of pressure cooking, each maintaining a gentle simmer for 1 hour after boiling, followed by filtering through gauze. The plant material is squeezed to extract remaining juice which is combined with the filtrate. The combined filtrate is brought to a boil and maintained at a gentle simmer while adding the edible canna flour solution. The optimal ratio of dried herb to edible canna flour is 1:1.3, which produces jelly with ideal firmness. 50g of dried herb yields approximately 3kg of jelly.

Edible canna flour from Wuping County, Longyan, produces jelly with better texture compared to corn starch or cassava starch, and receives superior sensory evaluation scores. Therefore, edible canna flour from Wuping County, Longyan, was selected for use.

Pressure cooking significantly reduces processing time compared to traditional cooking methods, offers good reproducibility, and is suitable for simulation and promotion.

After dried witch hazel was soaked in soda water for half an hour, it was boiled twice in a pressure cooker, and the filtrate from both boiling and the juice squeezed out from the witch hazel were mixed together to proceed to the step of adding starch to set the jelly. No need to boil it for the third time, as the addition of the filtrate and juice mixture from the third boiling had little effect on the setting of the jelly.

Given the multiple health benefits of *Mesona chinensis Benth.*, this experimental foundation can support further development of healthy products tailored for different sub-healthy populations, such as diabetics, patients with jaundice, kidney disease patients, and others. These experimental results also establish a foundation for the development of other *Mesona chinensis Benth.* health products.

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