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Study on the Processing Technology of Compounded Health Tea with Mango Peel

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Abstract: In order to better explore the use of mango peel, this study involves pre-treating mango peel and combining it with *Ganoderma lucidum* and hawthorn to produce a compounded health tea. Sensory evaluation, polysaccharide content, and total flavonoid content were used as indicators to explore the effects of single factors such as the mixing ratio of mango peel to *Ganoderma lucidum* (w:w), the number of blanching times for mango peel, and the ripeness level of mango peel on the sensory quality and health benefits of the compounded tea. Based on the results of single-factor experiments, an orthogonal experimental design was adopted with sensory score as the main evaluation index to determine the optimal processing conditions. The results showed that the best formulation for mango peel compound health tea was a mango peel to *Ganoderma lucidum* ratio of 6:4, two blanching treatments, and mango peel at 70%–80% ripeness. Under these conditions, the total flavonoid content of the tea reached 19.6 mg/g, the polysaccharide content was 4.62 mg/100g, and the tea water was cool, clear, mellow, and sweet.

Keywords: Mango peel; Compounded health tea; Processing technology

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1. Introduction

Mango (*Mangifera indica L.*), a well-known subtropical fruit, belongs to the Anacardiaceae family and is widely cultivated in regions such as Guangxi, Hainan, and Sichuan in China. Mango pulp is rich in vitamin C, minerals, essential amino acids, and dietary fiber. Currently, mangoes are primarily consumed as fresh fruit, while the peels and seeds are often discarded as waste, which not only reduces the overall utilization rate of mangoes but also contributes to environmental pollution.

However, mango peels contain a variety of bioactive compounds, including mangiferin, polyphenols, and flavonoids, which have been shown to exhibit antioxidant, anti-inflammatory, anticancer, antimicrobial, antitussive and expectorant, and immune-enhancing properties [1–9].

In this study, mango peel is used as the main raw material, with *Ganoderma lucidum* and hawthorn as supplementary ingredients, to process a health-promoting tea. The aim is to explore the optimal processing conditions for mango peel health tea and provide a reference for the effective utilization of mango peel.

2. Materials and methods

2.1. Materials and instruments

Mango peel: Tainong variety, sourced from Baise City, Guangxi Zhuang Autonomous Region.

Ganoderma lucidum and hawthorn: Supplied by Dashenlin Pharmaceutical Group Co., Ltd., Baise City, Guangxi Zhuang Autonomous Region.

Rutin (analytical reagent): Shanghai JinSui Biotechnology Co., Ltd.

Glucose (analytical reagent): Tianjin Zhiyuan Chemical Reagent Co., Ltd.

L6-S UV-Visible Spectrophotometer: Shanghai Analytical Instrument Co., Ltd.

2.2. Key processing steps

2.2.1. Process flow diagram

Ganoderma lucidum slicing → drying → grinding

Mango peel selection → blanching → drying → grinding → sieving → blending → packaging → sealing → inspection → finished product

Hawthorn slicing → drying → grinding

2.3. Operation procedures

2.3.1. Selection of raw materials

Ganoderma lucidum: Select high-quality, pure-colored, impurity-free Ganoderma slices. Dry the slices and grind them. Sieve through a 100-mesh screen, and store the powder in a cool, dark place at room temperature for later use.

Mango peel: Select healthy mango peels free from pests and diseases. Blanch in hot water, drain, and dry at a constant temperature of 95 °C. Then grind and sieve through a 100-mesh screen. Store at room temperature in the dark.

Hawthorn: Carefully select high-quality hawthorn slices. Dry, grind, and sieve through a 100-mesh screen. Store at room temperature in the dark.

2.3.2. Blending, packaging, and sealing

Blend the pretreated raw materials according to different ratios. After blending, package 2.5 g per bag. Seal the bags, inspect them, and obtain the finished product.

2.3.3. Sensory evaluation

Place the compound health tea into a teacup and brew with 200 mL of boiling water for 5 minutes. Filter to obtain the tea infusion. Select 10 trained sensory panelists to score the tea based on taste, color, and aroma. Calculate the average to obtain the final sensory evaluation score. The sensory evaluation criteria are shown in **Table 1**.

Table 1. Sensory evaluation criteria for health tea

Criterion	Standard	Score Range
Taste *(Max 33 points)*	Rich, pleasant, well-balanced flavor	23–33
	Full-bodied, no off-flavor, slight herbal taste	11–22
	Poor taste, strong herbal flavor	0–10
Color *(Max 33 points)*	Clear and bright, no sediment	23–33
	Dull, slight sediment present	11–22
	Cloudy, with significant sediment	0–10
Aroma *(Max 34 points)*	Rich and harmonious aroma	23–34
	Coordinated aroma, slight herbal note	11–22
	Weak aroma, overpowering herbal smell	0–10

2.4. Determination of total flavonoid content

2.4.1. Preparation of the rutin standard curve

The method was adapted based on Wang Jinghe et al. [10]. Precisely pipette 1.00 mL, 2.00 mL, 3.00 mL, 4.00 mL, and 5.00 mL of 0.3 mg/L rutin standard solution into separate 25 mL colorimetric tubes. To each tube, add 1.0 mL of 5% sodium nitrite solution, mix well, and let stand for 5 minutes. Then add 1.0 mL of 10% aluminum nitrate solution, mix, and let stand for another 5 minutes. Next, add 5 mL of 1.0 mol/L sodium hydroxide solution, mix well, and dilute to the mark with 95% ethanol. Mix again and let the mixture stand for 10 minutes. Using a reagent blank as the control, measure the absorbance at 510 nm. Take the rutin concentration (X) as the x-axis and absorbance (Y) as the y-axis to establish a linear regression equation.

2.4.2. Determination of total flavonoid content in health tea

Brew the prepared health tea with 200 mL of boiling water and filter to obtain the tea water. Accurately pipette 1.0 mL of the tea w and follow the color development method described in section 2.4.1. to measure absorbance. Calculate the total flavonoid content using **Formula 1**:

$$W_1 = C \times \frac{v_1}{m_1} \qquad \textbf{(Formula 1)}$$

Where:

W_1: Total flavonoid content per gram of tea infusion (mg/g)

C: Total flavonoid content in 1 mL of tea infusion (mg)

v_1: Total volume of filtered tea infusion (mL)

m_1: Weight of one bag of health tea (2.5 g)

2.5. Determination of polysaccharide content

2.5.1. Preparation of glucose standard curve

This method was adapted based on Zhang Ruigang et al., using the phenol-sulfuric acid method to determine the polysaccharide content in the health tea [11]. Prepare the standard curve by following the steps. Accurately pipetting 0.2 mL, 0.4 mL, 0.6 mL, 0.8 mL, and 1.0 mL of 0.01 mg/L glucose standard solution into 25 mL stoppered test tubes. Add water to bring the volume to 1.0 mL, then add 1.0 mL phenol solution. Quickly and carefully add 5 mL

of concentrated sulfuric acid. Let stand for 10 minutes, mix gently using a rotator mixer, then incubate in a 30 °C water bath for 20 minutes. Measure absorbance at 490 nm using a spectrophotometer, with a reagent blank as the reference, and a 1 cm cuvette. Use glucose concentration as the x-axis and absorbance as the y-axis to plot the standard curve and establish a linear regression equation.

2.5.2. Determination of polysaccharide content in health tea

Accurately pipette 1.0 mL of the tea water into a 25 mL stoppered test tube, follow the color development procedure in section 2.5.1., and measure the absorbance to calculate polysaccharide content using **Formula 2**:

$$W_2=\frac{m_2v_2}{m_3v_3}\times 0.9\times 10^{-4} \quad \textbf{(Formula 2)}$$

Where:

W_2: Polysaccharide content per 100 g of tea water (mg/100 g)

m_2: Polysaccharide content measured in 1 mL of tea water (μg)

v_2: Total volume of filtered tea water (mL)

v_3: Volume of tea water used in colorimetric analysis (mL)

m_3: Weight of one bag of health tea (2.5 g)

0.9: Conversion coefficient from glucose to glucan

2.6. Determination of single factors

2.6.1. Determination of the mango peel to Ganoderma lucidum ratio

Use mango peels with a ripeness level of 9–10, blanch twice, dry, grind, and sieve. Add hawthorn at 8%, and investigate the effects of different mixing ratios (5:5, 6:4, 7:3, 8:2, 9:1) of mango peel to *Ganoderma lucidum* on the quality of the health tea.

2.6.2. Determination of Mango Peel Ripeness

Blanch the mango peel twice, then dry, grind, and sieve. Mix mango peel and *Ganoderma lucidum* at a ratio of 6:4, and add 8% hawthorn. Investigate the effect of different mango ripeness levels (5–6, 7–8, 9–10) on the health tea.

2.6.3. Determination of blanching times for mango peel

Select mango peel with ripeness of 9–10, dry, grind, and sieve. Mix mango peel and *Ganoderma lucidum* at a 6:4 ratio, with 8% hawthorn added. Examine the effects of 0, 1, 2, 3, and 4 blanching treatments on the health tea.

2.7. Orthogonal experiment

Using sensory score as the evaluation index and based on the results of single-factor experiments, an L9(3^3) orthogonal experiment was designed to assess the influence of three factors: mango peel to *Ganoderma lucidum* ratio (A), mango ripeness (B), and number of blanching times (C), on the quality of the compound health tea.

3. Results and analysis

3.1. Effects of different mango Peel to Ganoderma lucidum ratios on the compounded health tea

As shown in **Figure 1**, the compounded health tea achieved the highest sensory evaluation score when the mango peel to *Ganoderma lucidum* ratio was 6:4. In contrast, the tea with a 9:1 ratio had the poorest taste performance. As the proportion of mango peel increased, the overall sensory score of the health tea gradually declined, indicating that an excessive amount of mango peel negatively affects the sensory quality of the tea.

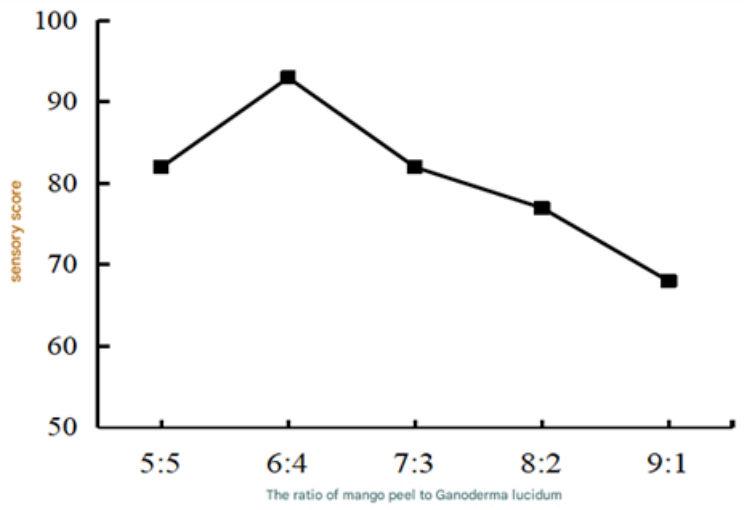

Figure 1. Effects of different mango peel to *Ganoderma lucidum* ratios on sensory scores

As shown in **Figure 2**, with the increase in mango peel content and the corresponding decrease in *Ganoderma lucidum* content, the polysaccharide content in the health tea decreased, while the total flavonoid content increased. This is primarily because *Ganoderma lucidum* is rich in polysaccharides, whereas mango peel contains higher levels of flavonoids. Based on these results, the mango peel to *Ganoderma lucidum* ratios of 5:5, 6:4, and 7:3 were selected for further orthogonal experiments.

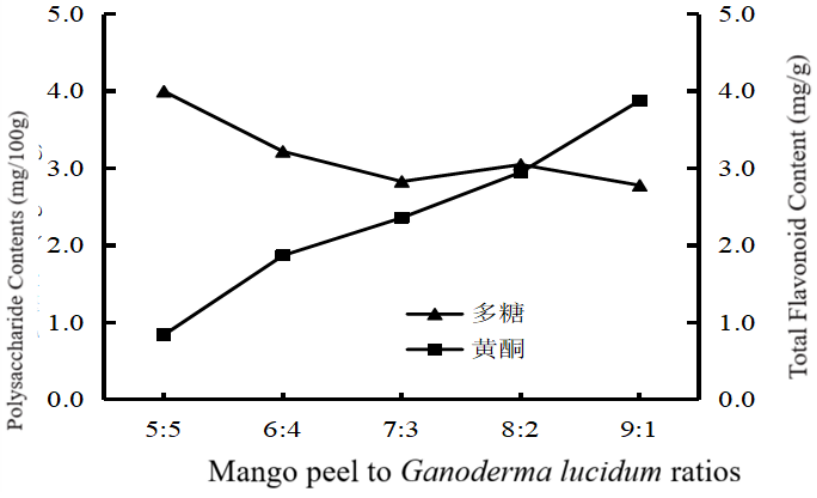

Figure 2. Impact of different mango peel to *Ganoderma lucidum* ratios on total flavonoid and polysaccharide contents in health tea

3.2. Effects of different mango ripeness levels on mango peel and Ganoderma lucidum health tea

As shown in **Figure 3**, the sensory scores increased with the ripeness of the mango peel. The highest sensory score was observed when the mango ripeness level reached 9–10.

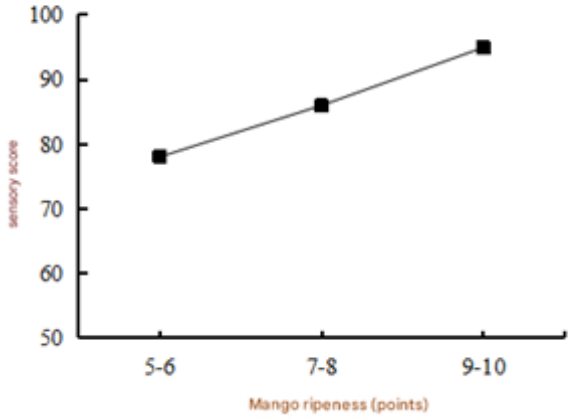

Figure 3. Effect of different mango ripeness levels on sensory scores

As shown in **Figure 4**, both the total flavonoid content and polysaccharide content of the health tea increased with the ripeness of the mango peel. Based on these results, mango ripeness levels of 5–6, 7–8, and 9–10 were selected for further orthogonal experiments.

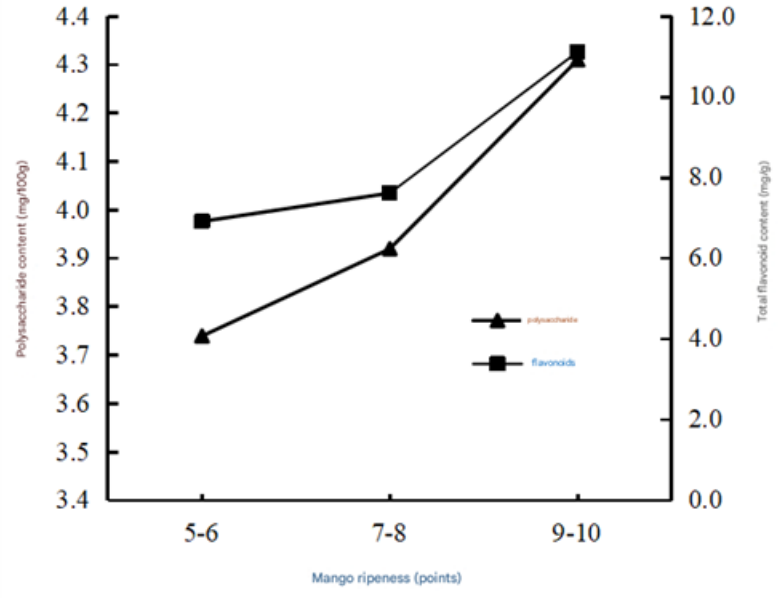

Figure 4. Effects of different mango ripeness levels on total flavonoid and polysaccharide contents

3.3. Effects of different blanching times on mango peel and Ganoderma lucidum health tea

As shown in **Figure 5**, the highest sensory score of the health tea was achieved when the mango peel was blanched

twice. When the blanching times were fewer than two, the sensory score increased with the number of blanchings; however, when the blanching times exceeded two, the sensory score decreased.

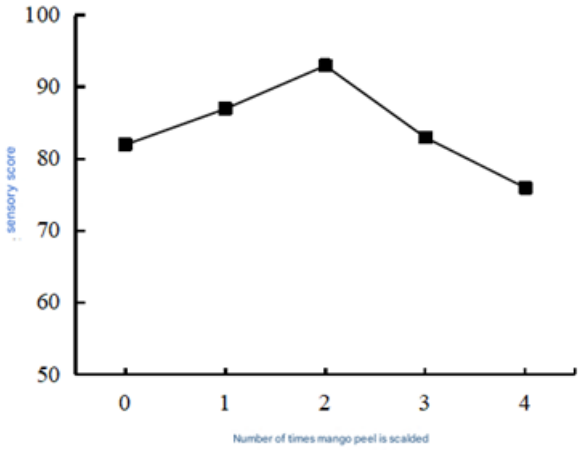

Figure 5. Effect of different blanching times of mango peel on sensory scores

As shown in **Figure 6**, the total flavonoid content of the health tea was highest when the mango peel was blanched twice. When blanching exceeded two times, the total flavonoid content decreased with additional blanching. Conversely, when blanching was fewer than two times, the total flavonoid content increased with more blanching. The highest polysaccharide content was observed when the mango peel was blanched once. When blanching exceeded one time, the polysaccharide content decreased as blanching increased. Insufficient blanching of mango peel leads to a bitter taste in the health tea, while excessive blanching causes greater loss of polysaccharides and total flavonoids. Based on these findings, blanching times of 1, 2, and 3 were selected for further orthogonal experiments.

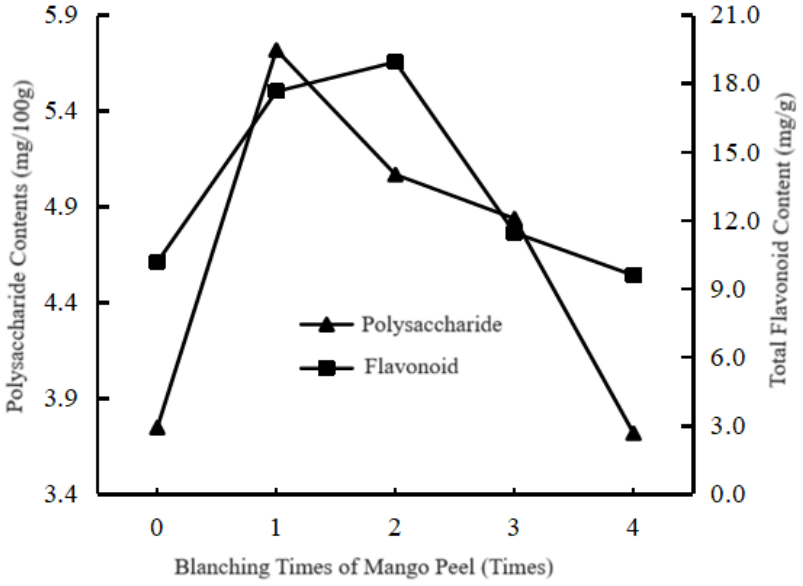

Figure 6. Effects of different blanching times of mango peel on total flavonoid and polysaccharide contents

3.4. Determination of orthogonal optimization test results

Based on the single-factor experiments, three factors were selected for the L9(3^3) orthogonal test: mango peel to *Ganoderma lucidum* mixing ratio (w:w), number of blanching times, and mango ripeness level. Each factor was tested at three levels. Sensory score was used as the evaluation index to observe changes in the quality of the health tea. The factor-level table for the orthogonal test is shown in **Table 2**.

Table 2. Factor levels for orthogonal test

Factor	A: Mango Peel to *Ganoderma lucidum* Ratio (w:w)	B: Number of Blanching Times	C: Mango Ripeness (Score)
1	7:3	1	5-6
2	6:4	2	7-8
3	5:5	3	9-10

As shown in **Table 3**, the factors affecting the quality of the health tea rank in the order of importance as C > B > A, meaning mango ripeness > blanching times > mango peel to *Ganoderma lucidum* ratio (w:w). The optimal formulation is A2B2C2, which corresponds to a mango ripeness of 9–10, two blanching treatments, and a mango peel to *Ganoderma lucidum* ratio of 6:4. The resulting compound health tea exhibits excellent color, aroma, and taste. The analysis of the orthogonal test results is presented in **Table 3**.

Table 3. Orthogonal test optimization results

Factors	Mango Peel to *Ganoderma lucidum* Ratio (W:W)	Blanching Times	Mango Ripeness (Score)	Total Sensory Score
1	1	1	1	82
2	1	2	2	89
3	1	3	3	85
4	2	1	2	93
5	2	2	3	85
6	2	3	1	80
7	3	1	1	84
8	3	2	3	86
9	3	3	1	78
K_1	85.3	86.3	82.0	
K_2	86.0	86.7	89.3	
K_3	82.7	81.0	82.7	
Range	3.3	5.7	7.3	
Order of influence on tea quality		C>B>A		
Optimal combination		$A_2B_2C_2$		

3.5. Validation test results

Based on the orthogonal test results, further validation tests were conducted. The sensory score of the health tea reached 94 points, which is basically consistent with the orthogonal test results. The optimal combination was

confirmed as mango ripeness of 7–8, two blanching treatments, and a mango peel to *Ganoderma lucidum* ratio (w:w) of 6:4.

3.6. Physicochemical indicators of the health tea

The compound health tea prepared under optimal conditions was measured to contain a total flavonoid content of 19.6 mg/g and a polysaccharide content of 4.62 mg/100 g.

4. Conclusion

The results of single-factor and orthogonal experiments indicate that the optimal process is to select mango peel with ripeness of 7–8, blanch the mango peel twice, and blend the mango peel and *Ganoderma lucidum* at a ratio of 6:4 (w:w). The health tea under these conditions is clear and bright, with a rich aroma and a mellow and sweet taste.

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Disclosure statement

The authors declare no conflict of interest.

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