

ORIGINAL RESEARCH ARTICLE

The development of low sugar bitter melon-green tea compound beverage

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ABSTRACT

With fresh bitter melon and green tea as main ingredients, xylitol, sucrose and citric acid as auxiliary ingredients, a new cool health tea beverage was developed. The optimum formula of low sugar bitter melon green tea compound beverage was developed by single factor experiment and orthogonal test based on sensory evaluation. The results showed that the optimum formula was as follows: Bitter melon juice was added at 7%, green tea extract was added at 20%, total xylitol and sucrose was 6% (mass ratio 1:1), citric acid was added at 0.2%, and the volume was fixed to 100% with de-ionized water. The product has light green color, harmonious aroma, moderate acidity and sweetness, and clear texture. The aftertaste is long, with tea polyphenol content of 342 mg/kg, soluble solids of 5.2% and pH 5.8.

Keywords: Bitter melon; Green Tea; Xylitol; Compound Beverage

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1. Introduction

Green tea beverage has a wide range of biological functions, such as improving thinking efficiency, stimulating the central nervous system, eliminating human free radicals, anti-aging, anti-bacterial, anti-cancer and so on, and is favored by the majority of consumers^[1-3]. However, with the development of society, consumers have put forward higher requirements for green tea drinks, requiring them to have more pleasant flavor and a wide range of physiological and health functions^[4-6]. Therefore, in this experiment, bitter melon juice and xylitol were added to the green tea extract to improve its flavor, reduce the sugar content and improve the health function, so as to provide a reference for the development of health tea beverage.

2. Materials and methods

2.1 Materials and reagents

Green tea (Xinyang Maojian), bitter melon and other materials are commercially available. Xylitol, sucrose, citric acid and vitamin C are all food grade, provided by the School of Biology and Food Engineering of Anyang Institute of Technology.

2.2 Instruments and equipment

FA2104 electronic balance is from the Shanghai Hengping Scientific Instrument Co., Ltd. LZ-1.5 double screw Juicer is from the Zhangjiagang Baiwo Machinery Co., Ltd. HH-1 digital display thermo-

static water bath pot is from the Changzhou Aohua Instrument Co., Ltd. L20 centrifuge is from the Hunan Xiangyi Laboratory Instrument Development Co., Ltd. RSTGN-3000 ultra-high temperature instantaneous sterilizer is from the Shanghai Yacheng Instrument Equipment Co., Ltd. BCD-215KA DZ Haier refrigerator is from the Beijing Haier Group. Bante922 precision pH meter is from the Shanghai Jiangyi Instrument Co., Ltd. And the 2JAJ Abbe refractometer is from the Shanghai Suofer Photoelectric Technology Co., Ltd.

2.3 Method

2.3.1 Process flow

Preparation of bitter melon juice: bitter melon selection → cleaning → pulp removal → segmentation → blanching → beating → color protection → filtration → bitter melon juice^[7].

Green tea treatment: green tea → weighing → extraction → filtration → secondary filtration → green tea extract.

General process flow: bitter melon juice, green tea extract, citric acid, xylitol and sucrose → mixing → centrifugal clarification → filling → sterilization → cooling → finished product.

2.3.2 Process key points

(1) Preparation of bitter melon juice

Selection and cleaning. Selecting the bitter melon with normal quality and no inferior quality, the green thick bitter melon with light bitter taste and seven to eight mature, we use clean water to clean the sediment on the surface and drain the water.

Cut open, remove the pulp and slice. Dividing the bitter gourd into two halves with a knife, removing the inner pulp and seeds, we cut the bitter gourd into 3–5 mm thick bitter gourd slices to facilitate juice extraction.

Salting and blanching. Soaking bitter melon slices in 6% salt solution for 50 min, then, we remove the bitter gourd and rinse it in boiling water for 1 min to remove the astringent substance^[8].

Beating and color protection. Quickly cooling the bitter gourd slices and putting them into the juicer, then, we add 3 times of deionized water for beating for 2 min. When it was juiced, adding

0.5% ascorbic acid to protect the color^[9].

Filtration. Filtering with 4 layers of gauze to remove a large amount of crude fiber in the bitter melon slurry and preparing bitter melon juice and after cooling, we place it in a 4 °C refrigerator for cold storage.

(2) Preparation of green tea extract

We select Xinyang Maojian green tea of good quality, heat the deionized water to about 85 °C, and then pour it into a beaker according to the ratio of 1:100 (mass ratio) of tea to water. Soaking it in a 85 °C water bathing for 15 min, and then we filter it with four layers of gauze to remove impurities and mixtures in the tea soup, so as to prepare the green tea extract, which is cooled and placed in a 4 °C refrigerator for cold storage^[10].

(3) Deployment

According to the designed experimental scheme, the bitter melon juice, green tea extract, citric acid, xylitol and sucrose are mixed evenly in a certain proportion, and the volume is fixed to 100% with deionized water.

(4) Centrifugal clarification

Using high-speed centrifugation technology, the feed liquid is added into the high-speed centrifuge tube and centrifuged at 4,000 r/min for 15 min to remove the impurities in the beverage.

(5) Sterilization and cooling

The microorganisms in bitter melon juice and tea extract are killed by ultra-high temperature instantaneous sterilizer. The sterilization temperature is 120–125 °C, and the treatment time was 3 s. Then the sterilized liquid is rapidly cooled to room temperature^[11].

(6) Packaging and finished products

The cooled liquid is quickly covered and sealed in a sterile environment to produce a low sugar bitter gourd green tea composite beverage.

2.3.3 Experimental design

(1) Single factor experiment

a) Determination of the addition amount of bitter melon juice

We fix the addition of 20% of green tea extract, 6% of total xylitol and sucrose, 0.15% of citric acid, and set the addition of bitter melon juice as 5%, 6%, 7%, 8% and 9% respectively, and fix the vol-

ume to 100% with deionized water. An evaluation team composed of 10 teachers and students majoring in Food Science and Engineering conducts sensory evaluation on its color, tissue state, taste and smell. The evaluation criteria are shown in **Table 1**, so as to determine the amount of bitter melon juice added in the orthogonal test.

b) Determination of the amount of green tea extract

From a), the highest score of bitter melon juice is fixed, the total amount of xylitol and sucrose is 6%, the amount of citric acid is 0.15%, the amount of green tea extract is 10%, 15%, 20%, 25% and 30%, and the volume is fixed to 100% with deionized water. The finished product is prepared after uniform mixing. The evaluation team conducts sensory evaluation on the color, organizational state, taste, smell, etc., of the product. The evaluation criteria are shown in **Table 1**, so as to determine the addition amount of green tea extract in the orthogonal test.

c) Determination of xylitol and sucrose addition

From a) and b), the highest scores of bitter melon juice and green tea extract are fixed, citric acid is added by 0.15%, different xylitol and sucrose (xylitol:sucrose = 1:1) are set as 4%, 5%, 6%, 7% and 8%, and the volume is fixed to 100% with deionized water. The finished product is pre-

pared after uniform mixing. The evaluation team conducts sensory evaluation on the color, organizational state, taste, smell, etc. of the product. The evaluation criteria are shown in **Table 1**, so as to determine the addition amount of xylitol and sucrose in the orthogonal test^[12].

d) Determination of citric acid addition

The addition amount of bitter melon juice, green tea extract, xylitol and sucrose with the highest score in 1), 2) and 3) is fixed, and the addition amount of citric acid is set as 0.10%, 0.15%, 0.20%, 0.25% and 0.30%, and the volume is fixed to 100% with deionized water. The finished product is prepared after uniform mixing. The evaluation team conducts sensory evaluation on the color, organizational state, taste, smell, etc. of the product. The evaluation criteria are shown in **Table 1**, so as to determine the addition amount of citric acid in the orthogonal test.

(2) Orthogonal test

The L9(3⁴) orthogonal test is conducted to determine the optimal proportion of low sugar bitter melon green tea compound beverage by adding the four main factors affecting the quality of low sugar bitter melon green tea compound beverage: Bitter melon juice, green tea extract, xylitol, sucrose and citric acid. Sensory scoring criteria are shown in **Table 1**.

Table 1. Sensory scoring criteria of low sugar bitter melon green tea complex beverage

Assessment items	Standard	Score
Color and texture (30 points)	Light green, cool and bright, no layering	25–30 points
	Light brown, with turbidity and no stratification	15–25 points
	Grayish brown, with precipitation and stratification	1–15 points
Taste (40 points)	It has the unique mixed flavor of bitter melon and green tea, without bitterness and astringency; the taste is delicate, not sticky, with a light bitter taste	30–40 points
	It has the mixed flavor of bitter melon and green tea, but it is bitter; the taste is not delicate	10–30 points
	The taste is not pure and has peculiar smell	1–10 points
Odor (30 points)	The aroma is rich, with the unique fragrance of fresh bitter melon and green tea	25–30 points
	Bitter melon or green tea have strong flavor	15–25 points
	No clear fragrance and peculiar smell	1–15 points

2.3.4 Product evaluation standards

(1) Sensory evaluation

The quality standard of low sugar bitter melon green tea compound beverage complies with GB/T21733-2008 *Tea Beverage*. The evaluation

indicators are color, smell, taste and tissue morphology. The percentage system is adopted and the average value is taken^[13]. Seen in **Table 1** for specific standards.

(2) Physical and chemical index evaluation

The physical and chemical evaluation standard of low sugar bitter melon green tea compound beverage is analyzed according to the methods specified in GB/T 21733-2008 *Tea Beverages* and GB/T 12143-2008 *General Methods for Analysis of Beverages*^[14]. In this experiment, the content of tea polyphenols is determined by the test method of tea polyphenols in tea drinks recorded in the national standard, The content of soluble solids is measured by Abbe refractometer, using a pH meter to measure pH.

3. Results and analysis

3.1 Single factor experimental results

3.1.1 Effect of bitter melon juice on product quality

The evaluation results are shown in **Table 2**.

Table 2. Effect of bitter melon juice addition on product quality

Serial number	Bitter melon juice addition amount/%	Comprehensive score/point
1	5	78
2	6	83
3	7	88
4	8	81
5	9	76

It can be seen from **Table 2** that with the increase of bitter melon juice, the sensory score of low sugar bitter melon green tea composite beverage first increased and then decreased. When the bitter melon juice was added at 7%, the sensory score of low sugar bitter melon green tea composite beverage reached the highest, and the product flavor was the best. We find a level value with equal interval above and below 7%, and take these three levels as the three levels of bitter melon juice addition in the orthogonal test, that is, 6%, 7% and 8% as the three levels of the orthogonal test.

3.1.2 Effect of green tea extract addition on product quality

The evaluation results are shown in **Table 3**.

Table 3. Effect of addition of green tea extract on product quality

Serial number	Green tea extract/%	Comprehensive score/point
1	10	70
2	15	76
3	20	87
4	25	83
5	30	78

It can be seen from **Table 3** that with the increase of the amount of green tea extract, the sensory score of the low sugar bitter melon green tea composite beverage first increased and then decreased. When the amount of green tea extract was 20%, the sensory score of the low sugar bitter melon green tea composite beverage reached the highest. At this time, the product tasted the best, which was basically consistent with the report in relevant data^[15]. We find a level value with the same interval above and below 20%, and take these three levels as the three levels of the addition of green tea extract in the orthogonal test, that is, 18%, 20% and 22% as the three levels of the orthogonal test.

3.1.3 Effect of xylitol and sucrose addition on product quality

The evaluation results are shown in **Table 4**.

Table 4. Effects of xylitol and sucrose addition on product quality

Serial number	Xylitol and sucrose addition amount/%	Comprehensive score/point
1	4	76
2	5	81
3	6	88
4	7	84
5	8	79

It can be seen from **Table 4** that with the increase of the total amount of xylitol and white granulated sugar, the sensory score of low sugar bitter melon green tea composite beverage first increased and then decreased. When the total amount of xylitol and white granulated sugar was 6%, the sensory score of low sugar bitter melon green tea composite beverage reached the highest, and the product flavor was the best. We find a level value with equal interval above and below 6%, and take these three levels as the three levels of orthogonal test, that is, 5%, 6% and 7% as the orthogonal

test. It can be seen from **Table 2** that with the increase of bitter melon juice, the three levels of low sugar bitter melon test.

3.1.4 Effect of citric acid addition on product quality

The evaluation results are shown in **Table 5**.

Table 5. Effects of citric acid addition on product quality

Serial number	Citric acid addition amount/%	Comprehensive score/point
1	0.10	76
2	0.15	81
3	0.20	86
4	0.25	82
5	0.30	78

It can be seen from **Table 5** that with the increase of citric acid addition, the sensory score of low sugar bitter gourd green tea composite beverage

first increased and then decreased. When the citric acid addition was 0.2%, the sensory score of low sugar bitter gourd green tea composite beverage reached the highest, and the product flavor was the best. We find a level value with equal interval above and below 0.2%, and take these three levels as the three levels of citric acid addition in the orthogonal test, i.e., 0.15%, 0.20% and 0.25% as the three levels of the orthogonal test.

3.2 Orthogonal test results

In the above single factor experiment, three levels of each factor were selected for L9(3⁴) orthogonal test based on the addition of bitter melon juice, green tea extract, citric acid, xylitol and sucrose. The orthogonal test results are shown in **Table 6**.

Table 6. Orthogonal test results of low-sugar bitter melon green tea beverage L9(3⁴)

Test No.	A Bitter melon juice/%	B Green tea extract	C Xylitol/% and /% white granulated sugar	D Citric acid/%	Comprehensive score/point
1	6	18	5	0.15	81
2	6	20	6	0.20	88
3	6	22	7	0.25	80
4	7	18	6	0.25	85
5	7	20	7	0.15	90
6	7	22	5	0.20	82
7	8	18	7	0.20	77
8	8	20	5	0.25	73
9	8	22	6	0.15	75
K ₁	249	243	236	246	
K ₂	257	251	248	247	
K ₃	225	237	247	238	
K ₁	83.0	81.0	78.6	82	
K ₂	85.7	83.7	82.7	82.3	
K ₃	75.0	79.0	82.3	79.3	
Range R	10.7	4.7	4.1	3.0	
Primary and secondary order			$A > B > C > D$		
Superior level	A ₂	B ₂	C ₂	D ₂	
Superior combination			$A_2B_2C_2D_2$		

It can be seen from **Table 6** that the No. 5 of the 9 samples in the L9(3⁴) orthogonal test has the highest score. Comparing the range *R* values in the table, it can be seen that the factors affecting the sensory quality of low sugar bitter melon green tea compound beverage are $A > B > C > D$ in the order of primary and secondary, that is, the amount of bitter melon juice added > the amount of green tea extract added > the total amount of xylitol and sucrose > the amount of citric acid added. The optimal combination of *K* value analysis is A₂B₂C₂D₂.

The optimum addition amount is 7% bitter melon juice, 20% green tea extract, 6% xylitol and sucrose, and 0.2% citric acid.

3.3 Verification test

According to the experiment, the best combination A₂B₂C₂D₂ is not among the 9 combinations in the orthogonal test, so it needs to be further verified with group 5 (A₂B₂C₃D₁) with the highest score in the orthogonal test table. We set group 5 in the orthogonal test table as sample 1, and the best com-

bination A₂B₂C₂D₂ obtained from the orthogonal test as sample 2 for confirmatory test. The results are shown in **Table 7**.

Table 7. Verification test

Serial number	Sensory score / point
1	90
2	92

It can be seen from **Table 7** that the sensory score of sample 2 is higher, so the combination of sample 2 is better, that is, the addition amount of bitter melon juice is 7%, the addition amount of green tea juice is 20%, the total amount of xylitol and sucrose is 6%, the addition amount of citric acid is 0.2%, and the volume is fixed to 100% with deionized water.

3.4 Optimal combination index

3.4.1 Sensory indicators

Color: soft light green.

Smell: it has the unique fragrance of green tea and bitter melon, and the aroma is harmonious.

Taste: pure taste, no astringency, moderate acidity and sweetness, and long aftertaste.

Organizational form: Clear and transparent, without stratification and impurities.

3.4.2 Physical and chemical indexes

The content of tea polyphenols is 342 mg/kg, soluble solids is 5.2%, pH 5.8, which meets the requirements of relevant national standards.

4. Conclusion

The primary and secondary order of the main factors affecting the experimental results is as follows: The amount of bitter melon juice added > the amount of green tea extract added > the total amount of xylitol and sucrose > the amount of citric acid added. The best technological combination of low sugar bitter melon green tea compound beverage is as follows: Bitter melon juice added 7%, green tea extract added 20%, total xylitol and sucrose added 6%, citric acid added 0.2%, and the volume was fixed to 100% with deionized water. The low sugar bitter melon green tea compound beverage prepared by this combination has light green color, harmonious aroma, moderate

acidity and sweetness, and clear texture. The after-taste is long, with tea polyphenol content of 342 mg/kg, soluble solids of 5.2% and pH5.8. The combination of bitter melon and green tea can make the functions of the two raw materials more coordinated and perfect, the color softer, and the nutrition complementary. Xylitol replaces part of sucrose, which can reduce the sucrose content in the drink. Because xylitol is not sugar, it does not take the metabolic pathway of sugar in the body, and will not cause the increase of blood sugar after eating, which is helpful to prevent the occurrence of diabetes, obesity, dental caries and cardiovascular diseases. The research and development of health tea beverage has extensive physiological regulation function meeting the needs of modern dietary characteristics of Chinese residents, and has broad development prospects.

Conflict of interest

The authors declare no conflict of interest.

References

1. Chen J, Guo R, Zhang J. Current situation and outlook of tea liquid drinks processing technology. *Journal of Anhui Agricultural Sciences* 2010; 38 (13): 6893–6895.
2. Cui B. Beverage technology. Beijing: Science Press; 2014. p. 127–128.
3. Ming X. Zhongguo mingcha pinjian sucha quashu (Chinese) [Quick reference book of Chinese famous tea]. Beijing: The Chinese Overseas Publishing House; 2014. p. 2830.
4. Huang J, Zhang F, Chen S, *et al.* Zhongguo chayinliao hangye xianzhuang yu zhanwang (Chinese) [Current situation and prospect of China's tea beverage industry]. *China Tea* 2017; 39(5): 29–31.
5. Ruan M, Xu H. Beverage technology. Beijing: China Light Industry Press; 2013. p. 368–371.
6. Ma L. Xiaofei xinli xuqiu xia chayinliao de yanjiu (Chinese) [Research on tea drinks under the consumer psychological]. *Tea in Fujian* 2016; 38 (9): 79–80.
7. Luo J, Zhang J. Research progress on application value and development of bitter melon. *The Food Industry* 2016; 37(10): 245–246.
8. Zeng J, Zhu X, Zhang M. Yinliao shengchan gongyi yu peifang (Chinese) [Beverage production process and formula]. Beijing: Chemical Industry Press; 2014. p. 247–248.
9. Liu C, Li X, Shan Y, *et al.* Study on processing technology of compound beverage “Sorrowful Feeling of Rose”. *Beverage Industry* 2016; 19(3):

- 22–23.
10. Zheng X, Zhang D, Sun Y, *et al.* Qincaiye, lvcha, li fuhe yinliao de yanzhi (Chinese) [Development of celery leaf, green tea and pear compound beverage]. *Journal of Shanxi Agricultural Sciences* 2016; 44(12): 1857–1859, 1863.
 11. Wang C, Zhao G, Sun L, *et al.* Production and application of functional sugar alcohol. *China Food Additives* 2012; 19(S1): 182–186.
 12. Du L. Gualei shipin jiagong jishu (Chinese) [Melon food processing technology]. Beijing: Chemical Industry Press; 2014. p. 125–126.
 13. Geng J, Lu Z. Preparation of honeysuckle and green tea compound beverage. *Food Industry* 2010; 31(4): 69–71.
 14. National Technical Committee 64 on Food Industry of Standardization Administration of China. GB/T 121143-2008 general analytical methods for beverages. Beijing: China Standards Press; 2008.
 15. Sun H, Wang X, Liu W. Optimization of processing technology and formulation of green tea-kiwi fruits compound beverage. *Science and Technology of Food Industry* 2014; 35(1): 227–231, 236.