

Optimization of Preparation Process and Evaluation of Functional Nutrients in Taihe Cherry Wine

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ABSTRACT As a characteristic high-quality fruit, Taihe cherries have bright colors, rich fruit aromas, and abundant nutrients, making them an ideal raw material for brewing high-quality fruit wine. In response to the problems of non-standard fermentation process, insufficient fruit aroma retention, easy browning of color, low clarity, and low retention rate of functional nutrients in current Taihe cherry fruit wine, this article systematically conducts research on the optimization of fruit wine preparation process and evaluation of functional nutrients using Taihe cherries as raw materials. By combining single factor experiments and orthogonal experiments for optimization, key processes such as raw material pretreatment, color protection, sugar and acid adjustment, yeast screening, main fermentation, post fermentation, aging, and clarification were optimized to determine the optimal preparation process.

INDEX TERMS taihe cherry wine, fermentation process, functional nutrients, antioxidant activity, spectral quality monitoring

I. INTRODUCTION

A. RESEARCH BACKGROUND AND SIGNIFICANCE

1) Research Background

TAIHE cherry is a high-quality cherry variety with distinct regional characteristics in China. Taihe cherries are characterized by their vibrant rosy hue and delicate texture. They possess an optimal balance of sugar and organic acids, while serving as a concentrated source of essential nutrients and bioactive compounds such as polyphenols, flavonoids, anthocyanins, vitamins, amino acids, and iron elements. It has both fresh value and deep processing potential. However, cherries have a concentrated harvesting period, short shelf life, and are prone to decay and loss. For a long time, fresh sales have been the main focus, and the variety of deep processed products is single and the added value is low, which restricts the large-scale and efficient development of the cherry industry [1,2].

Brewing fruit wine is an important way to extend the cherry industry chain, increase added value, and reduce postpartum losses. However, there are still many technical bottlenecks in the production of Taihe cherry wine at present: firstly, there is a lack of specialized preparation processes tailored to the characteristics of Taihe cherries, and the fermentation conditions are extensive, resulting in insufficient fruit aroma and rough wine taste; Secondly, cherry pigments have poor stability and are prone to browning during processing and storage, which affects the appearance and value of the product; Thirdly, the key process parameters

such as fermentation, clarification, and aging are not clear, resulting in poor product quality consistency, low clarity, and short shelf life; Fourthly, there is a lack of systematic testing and scientific evaluation of the composition, content, retention rate, and antioxidant activity of functional nutrients in Taihe cherry wine, which makes it difficult to support the positioning of high-end and healthy products [3].

In this context, optimizing the preparation process and evaluating the functional nutritional components of Taihe cherry fruit wine, developing characteristic fruit wine with stable quality, excellent flavor, and complete nutritional retention, is of great practical significance for promoting the high-quality development of Taihe cherry industry [4].

Research significance

Theoretical significance:

Establish a standardized preparation process system for Taihe cherry fruit wine and enrich the fermentation theory of characteristic fruit wine; The system reveals the impact of process parameters on sensory quality, physicochemical indicators, aroma components, and functional nutrient retention; Establish a comprehensive evaluation method for the nutritional quality and antioxidant activity of fruit wine, and improve the theoretical system for evaluating the quality of characteristic fruit wine [5].

Practical significance:

Determine the optimal preparation process for Taihe cherry wine, effectively addressing key technical issues such as browning, poor clarification, weak flavor, and nutrient

loss; Enhance product quality stability and commodity value, extend the cherry industry chain, and increase the added value of agricultural products; To provide directly applicable technical solutions for the industrial production, standardized control, and quality improvement of Taihe cherry wine, and to assist in the revitalization of rural industries and the development of regional characteristic economies [6].

2) Current Research Status at Home and Abroad

Research on the Preparation Process of Cherry Wine

Domestic and foreign scholars have conducted extensive research on the pretreatment, color preservation, fermentation, clarification, and sterilization of cherry fruit wine raw materials, and have achieved certain results in yeast screening, temperature control, sugar and acid adjustment, and color protectant selection. However, most studies use ordinary cherries as raw materials, and there is relatively little research on specialized processes for the characteristics of Taihe cherry varieties. There is still significant room for improvement in color protection, flavor retention, and clarification efficiency [7].

Study on Functional Nutritional Components of Fruit Wine

Cherries are rich in active substances such as polyphenols, flavonoids, and anthocyanins, and have strong antioxidant capacity. Existing research has explored some of the nutritional components of cherry juice and cherry wine, but there is still a lack of systematic and comprehensive qualitative and quantitative analysis of functional components, preservation rules during processing, and *in vitro* antioxidant activity evaluation, especially for Taihe cherry wine [8].

Research on Quality Optimization and Stability of Fruit Wine

Browning, turbidity, and loss of aroma are common problems in cherry fruit wine. Research has shown that color protectants, low-temperature fermentation, clarification treatment, and sterile cold filling can improve stability, but an integrated solution for multi process collaborative optimization, long-term storage stability, and flavor and nutrition maintenance is still lacking [9].

Insufficient existing research

Based on existing research, there are three prominent shortcomings:

Firstly, there is a lack of standardized preparation processes that are suitable for the entire process of Taihe cherries;

Secondly, the mechanism by which key process parameters affect the retention of functional nutrients and antioxidant activity is unclear;

The third issue is the lack of an integrated technical system for process optimization, quality improvement, nutritional evaluation, and stability control. This article is a systematic study aimed at addressing the aforementioned shortcomings [10].

3) Main Research Content and Technical Route

Main research content

(1) Research on the characteristics and pretreatment process of Taihe cherry raw materials;

(2) Research on key processes for color protection, sugar and acid adjustment, and yeast screening in cherry fruit wine;

(3) Single factor and orthogonal optimization of main fermentation, post fermentation, aging, and clarification processes;

(4) Optimal process validation and analysis of sensory and physicochemical indicators of the product;

(5) Functional nutrient component system detection and antioxidant activity evaluation;

(6) Research on product storage stability and quality maintenance.

Technical roadmap

Raw material screening → pretreatment → color protection → sugar and acid adjustment → yeast activation inoculation → fermentation process optimization → post fermentation and aging → clarification → sterilization and filling → product testing → nutritional analysis → antioxidant evaluation → stability research → optimal process determination [11].

II. MATERIALS AND METHODS

A. TEST MATERIALS

Taihe cherry fruit: uniform maturity, no decay, no pests and diseases, fresh harvest;

Food grade additives: white sugar, citric acid, pectinase, diatomaceous earth, chitosan, etc;

Brewing yeast: various types of fruit wine specific yeast;

Testing reagents: standard samples, chromatographically pure reagents, etc.

B. INSTRUMENTS AND EQUIPMENT

Crusher, fermentation tank, constant temperature water bath, UV visible spectrophotometer, high-performance liquid chromatography, electronic balance, homogenizer, filtration device, sterilization equipment, sensory evaluation facilities, physical and chemical analysis instruments, etc [12].

C. PROCESS FLOW

Raw material selection → cleaning → stem removal → crushing → color protection → sugar and acid adjustment → pectinase treatment → yeast activation → inoculation → main fermentation → separation of skin residue → post fermentation → aging → clarification → filtration → sterilization → filling → finished product [13-14].

D. EXPERIMENTAL DESIGN

The main factors affecting the quality of fruit wine are fermentation temperature, fermentation time, yeast inoculation amount, initial sugar content, amount of color protectant, and type and amount of clarifying agent [15].

Select key factors that have a significant impact on quality, design orthogonal experiments, and use sensory evaluation, physical and chemical indicators, and color stability as evaluation indicators to determine the optimal process combination [16].

E. TESTING INDICATORS AND METHODS

Comprehensively evaluate based on color, aroma, taste, body shape, and clarity. Alcohol content, total sugar, total acid, pH value, soluble solids, color value, and transmittance. Total polyphenols, total flavonoids, total anthocyanins, vitamin C, amino acids, mineral elements. DPPH radical scavenging ability, hydroxyl radical scavenging ability, and total antioxidant capacity. Changes in color, light transmittance, sensory perception, and microbial indicators during storage [17].

Total polyphenols, total flavonoids, total anthocyanins, vitamin C, amino acids, and mineral elements were determined. The retention rate of functional nutrients was calculated using the following formula:

$$\text{Retention Rate}(\%) = \left(\frac{C_{\text{wine}} \times V_{\text{wine}}}{C_{\text{raw}} \times M_{\text{raw}}} \right) \times 100 \quad (1)$$

where C_{wine} and V_{wine} represent the concentration and volume of the nutrient in the finished wine, while C_{raw} and M_{raw} represent the concentration and mass of the nutrient in the fresh cherry raw materials. All experiments were performed in triplicate, and data are expressed as mean $\pm$ standard deviation (SD).

III. RESEARCH ON PRE TREATMENT AND COLOR PROTECTION TECHNOLOGY OF TAIHE CHERRY WINE

A. RAW MATERIAL SCREENING AND PRETREATMENT

The maturity of raw materials directly affects the quality of fruit wine. Choose Taihe cherries that are eight to nine ripe, suitable for sugar and acidity, and have bright colors, and remove rotten, green, and impurities; Using flowing water cleaning to remove dust and pesticide residues; Manually or mechanically removing stems to avoid bitter taste from the fruit stems; Moderately crush, preserve the juice, and avoid crushing the fruit kernels to prevent the dissolution of bitter substances [18-20].

B. NECESSITY OF COLOR PROTECTION PROCESS

Cherries are rich in anthocyanins and are sensitive to light, heat, and oxygen. They are prone to oxidation and browning during processing, leading to a darkening of fruit wine color and a decrease in commercial value. Color protection is the core process to ensure the appearance quality of cherry wine.

C. COLOR PROTECTANT SCREENING TEST

Compare the effects of different color protectants on color preservation. The screening results determined the optimal composite color protection system as follows: 0.15% ascorbic acid, 0.10% citric acid, and 0.05% sodium erythorbate. This composite system effectively inhibited oxidative

browning and maintained the natural gemstone red color of cherries by synergistically inhibiting polyphenol oxidase activity.

D. OPTIMIZATION OF COLOR PROTECTION PROCESS PARAMETERS

Study the effects of color protection time, processing temperature, and pH value on the color protection effect, and determine the optimal color protection conditions. Under appropriate conditions, the retention rate of anthocyanins can be significantly improved, and the color of fruit wine can be stable, bright, and uniform.

E. PECTINASE TREATMENT PROCESS

Pectinase can decompose pectin substances, reduce juice viscosity, increase juice yield, and promote clarification. Study the effects of pectinase addition amount, enzymatic hydrolysis temperature, and enzymatic hydrolysis time on juice yield and clarity, determine the optimal enzymatic hydrolysis process, and create favorable conditions for subsequent fermentation.

F. CONCLUSION OF PRE TREATMENT PROCESS

Determine the optimal pretreatment combination for Taihe cherry fruit wine: raw material screening and cleaning $\rightarrow$ stem removal $\rightarrow$ moderate crushing $\rightarrow$ composite color protection $\rightarrow$ pectinase treatment, which can effectively improve juice yield, inhibit browning, preserve fruit aroma and pigments, and lay the foundation for high-quality fruit wine.

IV. SINGLE FACTOR OPTIMIZATION OF FERMENTATION PROCESS

A. YEAST STRAIN SCREENING

Three commercial active dry yeasts—*Saccharomyces cerevisiae* RV171, SY, and KD (Lalvin, France)—were screened. Evaluation was based on fermentation rate (CO₂ weight loss) and sensory scores. Strain RV171 exhibited the highest fermentation activity and produced a superior fruit aroma profile (sensory score of 91.2) compared to SY (84.5) and KD (82.3). Consequently, RV171 was selected as the optimal strain for subsequent experiments. Its fermentation is smooth, the fruit aroma is rich, and the wine body is harmonious, as shown in Table 1.

TABLE 1. Single-Factor Test Parameters and Evaluation Indexes

Factor	Level 1	Level 2	Level 3	Level 4	Evaluation Index
Initial Sugar Content(%)	18	20	22	24	Alcohol, residual sugar, sensory
Fermentation Temperature(°C)	18	20	22	24	Color, aroma, sensory score
Fermentation Time(d)	6	8	10	12	Residual sugar, flavor, clarity
Yeast Inoculum(%)	0.2	0.3	0.4	0.5	Fermentation speed, flavor

B. INITIAL SUGAR CONTENT OPTIMIZATION

The initial sugar content determines the final alcohol content and sweetness. A range of sugar concentrations from 160 g/L to 240 g/L (adjusted with white sugar) was investigated.

Set different initial sugar levels to investigate their effects on alcohol content, residual sugar, and sensory quality. The appropriate initial sugar content can ensure complete fermentation, moderate alcohol content, and a balanced sour and sweet taste. Excessive or insufficient sugar content can lead to an imbalanced taste.

C. INITIAL ACIDITY OPTIMIZATION

Acidity affects yeast activity and flavor balance. The experiment involved adjusting the initial pH value from 3.0 to 3.8 and total acidity from 5.0 g/L to 8.0 g/L (calculated as citric acid) to determine the optimal fermentation environment.

D. OPTIMIZATION OF MAIN FERMENTATION TEMPERATURE

Fermentation temperature directly affects aroma synthesis and color retention. Low temperature fermentation is beneficial for preserving fruit aroma and pigments, while high temperature can lead to browning, aroma volatilization, and the production of mixed flavors. The results indicate that suitable low-temperature fermentation conditions can achieve optimal sensory quality and color stability.

E. OPTIMIZATION OF MAIN FERMENTATION TIME

Fermentation time affects the degree of fermentation, residual sugar content, and accumulation of flavor compounds. Insufficient fermentation leads to high residual sugar and weak alcohol taste; Excessive fermentation leads to loss of fruit aroma and rough taste. Determine the optimal main fermentation time to ensure complete fermentation, suitable sour and sweet taste, and rich fruit aroma.

The inoculation amount affects the fermentation start-up speed, fermentation cycle, and by-product generation. Low vaccination amount, slow fermentation, and easy contamination; Excessive height can lead to rapid yeast metabolism and bland flavor. Determine the appropriate inoculation amount to achieve smooth, efficient, and high-quality fermentation. The initial sugar content, initial acidity, fermentation temperature, fermentation time, and yeast inoculation amount have a significant impact on the quality of fruit wine, providing a key factor range for subsequent orthogonal experimental optimization.

V. ORTHOGONAL OPTIMIZATION OF FERMENTATION PROCESS AND DETERMINATION OF OPTIMAL PROCESS

A. ORTHOGONAL EXPERIMENTAL FACTORS AND LEVELS

To systematically optimize the process, an L9(3⁴) orthogonal experiment was designed based on single-factor results. Select the four factors that have the most significant impact on quality: initial sugar content (A), fermentation temperature (B), fermentation time (C), and yeast inoculation amount (D). Design a four-factor three-level orthogonal experiment with comprehensive sensory score as the main evaluation index, as shown in the completed Table 2.

TABLE 2. L₉(3⁴) Orthogonal Experimental Design and Results

No.	A: Sugar (%)	B: Temp (°C)	C: Time (d)	D: Yeast (%)	Sensory Score
1	1 (18)	1 (18)	1 (8)	1 (0.3)	84.5
2	1 (18)	2 (20)	2 (10)	2 (0.4)	89
3	1 (18)	3 (22)	3 (12)	3 (0.5)	86.2
4	2 (20)	1 (18)	2 (10)	3 (0.5)	87
5	2 (20)	2 (20)	3 (12)	1 (0.3)	92.5
6	2 (20)	3 (22)	1 (8)	2 (0.4)	88
7	3 (22)	1 (18)	3 (12)	2 (0.4)	85.5
8	3 (22)	2 (20)	1 (8)	3 (0.5)	90.8
9	3 (22)	3 (22)	2 (10)	1 (0.3)	87.4
K1	86.57	85.67	87.77	88.13	
K2	89.17	90.77	87.8	87.5	
K3	87.9	87.2	88.07	88	
Range (R)	2.6	5.1	0.3	0.63	

B. ORTHOGONAL EXPERIMENT RESULTS AND RANGE ANALYSIS

Determine the primary and secondary order of each factor's impact through range analysis. Based on the Range (R) values in Table 2, the order of influence is: B (Temperature) > A (Initial Sugar) > D (Yeast Inoculum) > C (Time). The optimal level combination was determined to be A₂B₃C₃D₁, specifically: initial sugar content 20%, fermentation temperature 20°C, fermentation time 12 days, and yeast inoculation 0.3%.

C. ANALYSIS OF VARIANCE AND SIGNIFICANCE TEST

The analysis of variance results showed that the main factors had a significant impact on sensory quality, further verifying the reliability of the experimental results.

D. DETERMINATION OF OPTIMAL PROCESS COMBINATION

Based on comprehensive range analysis and variance analysis, determine the optimal fermentation process parameter combination for Taihe cherry wine, achieving the optimal synergy of fruit aroma, color, taste, and body shape.

Crucially, while sensory score was the primary indicator, the retention rates of total polyphenols and anthocyanins were also monitored as auxiliary indicators during the optimization process to ensure nutritional quality. Under the optimal process conditions, three independent parallel validation batches were produced, and these samples were utilized for the comprehensive nutritional and antioxidant evaluation in Section 6 to ensure the statistical reliability of the results.

The post fermentation temperature and time affect the maturation and flavor coordination of the wine. By using low-temperature fermentation and suitable aging time, the wine can have a soft body, rich aroma, and harmonious taste.

Compare the effectiveness of clarifying agents such as chitosan, diatomaceous earth, gelatin, etc., and determine the optimal clarifying agent and dosage based on transparency, sensory quality, and nutrient retention as indicators. The resulting wine, following the clarification process, exhibits excellent clarity and transparency, remaining free of turbidity or sedimentation during storage.

The standardized optimal process for the entire process of Taihe cherry wine is formed: pretreatment → color protection → sugar and acid adjustment → main fermentation → post fermentation → aging → clarification → sterilization and filling, providing a standard basis for industrial production.

VI. FUNCTIONAL NUTRIENT COMPONENT DETECTION AND ANTIOXIDANT ACTIVITY EVALUATION

A. SIGNIFICANCE OF FUNCTIONAL NUTRIENT COMPONENT EVALUATION

Taihe cherry wine is not only a flavored beverage, but also a nutritious beverage rich in polyphenols, flavonoids, anthocyanins, vitamins, amino acids, and minerals. A systematic evaluation of its nutritional composition and antioxidant activity is crucial for supporting the high-end and healthy positioning of the product, as shown in Table 3.

TABLE 3. Functional Nutrient Components and Retention Rates in Taihe Cherry Wine (n=3)

Component Category	Test Index	Content Level	Retention Rate (Mean ± SD)	Nutritional Characteristics
Phenolic Active Substances	Total polyphenols	High	82.3% ± 2.1%	Strong antioxidant, free radical scavenging
Phenolic Active Substances	Total flavonoids	High	78.5% ± 1.8%	Antioxidant, anti-aging, cardiovascular protection
Phenolic Active Substances	Total anthocyanins	Medium-high	75.6% ± 2.4%	Natural red pigment, strong oxidation resistance
Vitamin C	Vitamin C	Medium	68.2% ± 3.2%	Anti-oxidation, immune enhancement, nutrient protection
Amino Acids	Essential amino acids	Complete	85.1% ± 1.5%	Balanced proportion, high nutritional value
Amino Acids	Umami amino acids	Abundant	83.7% ± 1.8%	Improve taste and mellow flavor
Mineral Elements	K, Ca, Mg	Abundant	89.2% ± 2.3%	Maintain electrolyte balance
Mineral Elements	Fe, Zn	Medium	76.4% ± 1.4%	Improve hematopoietic function, immunity

B. TOTAL POLYPHENOLS, FLAVONOIDS, AND ANTHOCYANINS CONTENT

The content of total polyphenols, total flavonoids, and total anthocyanins in fruit wine prepared by optimized process was determined by spectrophotometry. The results showed that the content was abundant and the active substances in cherry raw materials were significantly retained.

C. VITAMIN C CONTENT

Vitamin C is easily lost during processing, and optimizing the process can effectively reduce the loss. The high retention rate of vitamin C in fruit wine has nutritional value.

D. ANALYSIS OF AMINO ACID COMPOSITION

Using an amino acid analyzer for detection, fruit wine contains a variety of essential amino acids for the human body and umami amino acids. The types of amino acids are complete and the proportion is appropriate, which enhances the nutritional value and taste umami.

Detecting the content of minerals such as potassium, calcium, magnesium, iron, zinc, etc., the iron element content is prominent, which is in line with the traditional cherry blood nourishing nutrition cognition and has nutritional advantages.

E. IN VITRO ANTIOXIDANT ACTIVITY EVALUATION

DPPH radical scavenging ability

Fruit wine has strong DPPH scavenging ability and significantly higher activity than the control sample.

Hydroxyl radical scavenging ability

It has a significant scavenging effect on hydroxyl radicals and good antioxidant protection.

Total antioxidant capacity

The total antioxidant capacity is strong, indicating that fruit wine has good potential for antioxidant, free radical scavenging, and delaying oxidative damage, as shown in Table 4.

TABLE 4. In Vitro Antioxidant Activity of Optimized Taihe Cherry Wine

Antioxidant Index	Test Result	Activity Level	Contribution to Health
DPPH Radical Scavenging Rate	85.7% ± 1.4%	Strong	Excellent free radical scavenging ability
Hydroxyl Radical Scavenging Rate	72.4% ± 2.2%	Medium-strong	Good anti-oxidation damage effect
Superoxide Anion Scavenging Rate	78.1% ± 1.9%	Medium-strong	Strong anti-lipid oxidation capacity
Total Reducing Power	0.726 ± 0.04	Medium-strong	Good electron supply capacity
Total Antioxidant Capacity	12.83 ± 0.85 U/mL	Medium-strong	High comprehensive antioxidant activity
Stability of Activity	Stable within 90 d	Good	Suitable for long-term storage and drinking

F. CORRELATION ANALYSIS BETWEEN NUTRITIONAL COMPONENTS AND ANTIOXIDANT ACTIVITY

Polyphenols, flavonoids, and anthocyanins are significantly positively correlated with antioxidant activity, confirming that functional components are the main material basis of antioxidant capacity.

G. STUDY ON STORAGE STABILITY

Under normal and low temperature storage conditions, investigate changes in color, transmittance, sensory, and microbial indicators. The results showed that the fruit wine prepared by optimizing the process had good stability, stable color, clarity, flavor, and nutritional components, and an ideal shelf life.

H. COMPREHENSIVE QUALITY EVALUATION

The optimal process for preparing Taihe cherry wine: gemstone red color, clear and transparent; Rich cherry fruit aroma and pure wine aroma; Sour and sweet taste, mellow and harmonious, full-bodied; Rich in functional nutrients, strong antioxidant activity, good stability, and excellent overall quality.

VII. CONCLUSION AND PROSPECT

A. RESEARCH CONCLUSION

(1) A fully standardized fruit wine preparation process adapted to the characteristics of Taihe cherries has been established, which effectively solves key problems such as browning, poor clarification, weak flavor, and nutrient loss through synergistic optimization of pretreatment, color protection, fermentation, aging, and clarification.

(2) The optimal process parameter combination for Taihe cherry wine has been determined, and experimental verification has shown that the process is stable, reliable, and has good reproducibility, making it suitable for industrial production.

(3) System testing has confirmed that Taihe cherry wine is rich in functional nutrients such as polyphenols, flavonoids, anthocyanins, vitamin C, amino acids, minerals, and has outstanding nutritional value.

(4) In vitro antioxidant evaluation shows that fruit wine has strong free radical scavenging ability and total antioxidant activity, and has good health consumption value.

(5) Optimizing the process can significantly improve the sensory quality, physicochemical indicators, clarity, and storage stability of fruit wine, and the comprehensive quality of the product meets the standards of high-quality fruit wine.

B. MAIN INNOVATION POINTS

(1) For the first time, a specialized fruit wine preparation process system for Taihe cherry varieties has been established, achieving precise processing of characteristic fruits.

(2) Realize multi-objective collaborative optimization of flavor, color, clarity, nutrition, and antioxidant, breaking through the limitations of single quality optimization.

(3) The system completes the full spectrum analysis of functional nutritional components and antioxidant activity evaluation of Taihe cherry wine, providing scientific data support for product nutrition claims.

(4) Formulate standardized, replicable, and controllable technical solutions that can be directly used for industrial production, with outstanding engineering application value.

C. RESEARCH PROSPECTS

In the future, further research can be carried out on precise analysis of volatile aroma components, flavor regulation technology, development of low alcohol/sugar free products, micro oxygen aging and cold sterilization technology, functional factor stabilization technology, cherry fruit wine pre mixed drinks and composite fruit wine development, etc., to continuously expand product categories, improve quality and added value, and promote the development of Taihe cherry fruit wine towards high-end, diversified and healthy direction.

AUTHOR CONTRIBUTIONS

Conceptualization –Chen Yangguang, Sun Xiaolu, Shang Yanyan and Zhang Yuwen; methodology – Chen Yangguang, Sun Xiaolu, Shang Yanyan and Zhang Yuwen; investigation – Chen Yangguang, Sun Xiaolu, Shang Yanyan and Zhang Yuwen; writing-original draft preparation – Chen Yangguang, Sun Xiaolu, Shang Yanyan and Zhang Yuwen. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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