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ORIGINAL ARTICLE

An Analytic Hierarchy Process Multi-criteria Quantitative Evaluation Model of Cinnamon Decoction Pieces

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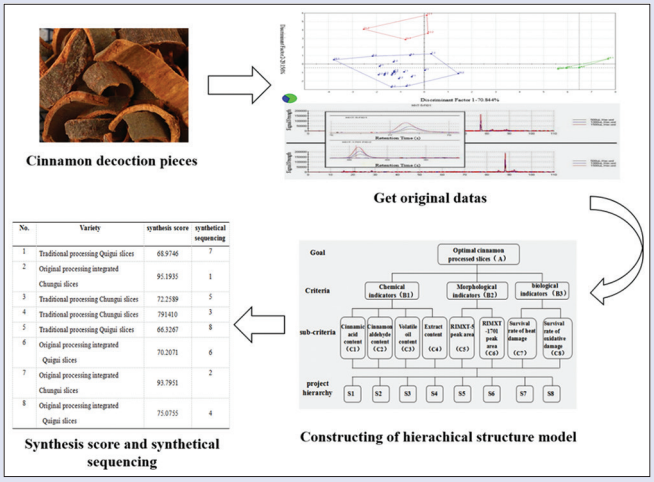
ABSTRACT

Background: The dried bark of *Cinnamomum zeylanicum* is a well-known medicinal constituent owing to its latent health benefits. The establishment of a wide-ranging and objective quality assessment method is a tricky to be solved instantly by cinnamon and other medicinal and edible herbs. **Objectives:** The objective was to introduce the analytic hierarchy process (AHP) to estimate widely and compare the quality of cinnamon decoction pieces. **Materials and Methods:** The chemical, morphological, and biological indexes of different batches of cinnamon decoction pieces are determined, and then a multi-criteria quantitative assessment model for the quality estimation of cinnamon decoction pieces is documented by adopting AHP. **Results:** The complete appraisal outcomes of AHP model are dependable with objective evaluation, and the results are unbiased and steady. **Conclusion:** The AHP multi-criteria quantitative evaluation model can be agreeably adapted to the quality evaluation of multi-component Chinese herbal decoction pieces, providing a new evidence for the quality evaluation of traditional Chinese medicine.

Key words: AHP, cinnamon, multi-criteria, quality evaluation, traditional Chinese medicine



SUMMARY

- This experiment attempts to construct a model to evaluate the quality of cinnamon decoction pieces and uses an analytic hierarchy process combined with multi-index quantitative methods to rank different batches of cinnamon decoction pieces. The results suggest that the model is reliable and provides new ideas and methods for the evaluation of traditional Chinese medicine decoction pieces.

Abbreviations used: AHP:Analytic hierarchy process; TCM:traditional Chinese medicine;DFA:discriminant factor analysis; NGM:nematode growth medium; C. elegans: Caenorhabditis elegans;FID: Flame ionization detector.

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INTRODUCTION

The dried bark of *Cinnamomum cassia* Presl is extensively employed as a medicinal ingredient throughout the world. Cinnamon has been encompassed in the pharmacopeia of many countries and regions. Due to its medicinal and nutritional values, cinnamon is employed as an aromatic food and pharmaceutical ingredient. Due to its current increasing demand, some cinnamon confusions, substitutes, and inferior products are repeatedly sold in the market, leading to serious quality-related concerns. Therefore, an inclusive and effective quality evaluation system must be established to confirm the effectiveness and safety of cinnamon.

The quality of cinnamon is verified mostly by engaging cinnamaldehyde and cinnamic acid as the indicators;[1] this method cannot widely assess the quality of cinnamon. Our study was intended at introducing the AHP for the multi-index comprehensive estimation of cinnamon decoction pieces. The chemical, character, and biological indicators can estimate the cinnamon decoction pieces. According to the weight of each index,[2] we dogged the degree of mutual influence between the system factors or the contribution of different factors to the evaluation system, reduced the interaction between numerous test factors, and thus recognized a quality evaluation method for the cinnamon decoction pieces.

Many studies have revealed that the volatile oils are major medicinal substances in the cinnamon bark. Cinnamaldehyde and cinnamic acid are the major volatile constituents of cinnamon.[1] According to the Chinese Pharmacopeia 2020, cinnamaldehyde is employed as the quality control index. Recent studies have stated that the water extracts of cinnamon possess noteworthy pharmacological activities. Therefore,

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the content of water-soluble extract, together with cinnamaldehyde and cinnamic acid cited above, was added as the chemical index of quality evaluation of cinnamon in this study. Cinnamon has a strong odor and clear phenotypic features because of its high content of volatile oil. Its odor appearances are straight related to the chemical components enclosed in cinnamon and also thoroughly related to the intrinsic quality and drug efficacy, such as "Cinnamon with strong aroma has good quality and good efficacy," therefore, the odor is employed as the character index of cinnamon. In this study, an electronic nose system was used for the speedy and precise detection of different cinnamon samples. In addition, the antioxidant[3] and antipyretic[4] effects of cinnamon are typically assessed by *in vitro* experiments, such as cell culture. However, *in vitro* experiments are simply exaggerated by the external environment and they cannot fully imitate the inclusive efficacy of cinnamon. For *in vivo* studies, *Caenorhabditis elegans* (hereinafter referred to as nematode) is employed for screening the activity of Traditional Chinese Medicine (TCM).[5] Compared to other model organisms, it can evade errors caused by individual differences, which is fairly helpful for standardizing a bioassay. Moreover, nematodes comprise most of the human disease genes and disease pathways and thus they can aid as model animals for studying antioxidants[6] and various diseases.[7,8] In this study, the nematodes were unprotected to volatile oils from different decoction samples and their survival rate was determined through oxidative stress and heat stress tests. Our study can act as a reference for the imminent application of nematodes for fast bioassays of TCM.

Finally, based on the chemical composition, morphological characteristics, and biological activity of cinnamon, we smeared AHP to launch a comprehensively evaluation model of cinnamon decoction pieces for the first time. In the meantime the quality of the eight batches of cinnamon decoction samples was assessed. This method delivers a theoretical basis for the quality estimation of cinnamon pieces and travels a new way for the quality valuation of TCM decoction pieces.

MATERIALS AND METHODS

Chemicals and materials

In this study, four species of cinnamon decoction samples were organized, namely Chungui decoction pieces prepared by integrated primary processing method (hereinafter called "integration" for short), Qiugui integrated decoction pieces, Chungui traditional decoction pieces, and Qiugui traditional processing decoction pieces. Here, the fresh cinnamon samples were gnarled with water and then dried to achieve a water content of 40% to 45%. Then, the rough bark was scraped off and the samples were cut into 2–3 mm filaments and then converted to integrated decoction pieces. The cinnamon decoction pieces were desiccated at 50°C, crushed, and sealed for future use. Fresh cinnamon samples were eroded with water and dried to <15% moisture content. The impurities and the rough bark were separated. Then, the samples were unstiffened using the cold-soaking method under abridged pressure. The soft cinnamon samples were cut into 2–3 mm filaments, then made into traditional processing decoction pieces. The traditional processing decoction pieces were dehydrated at 50°C, crushed, and sealed for upcoming use. The details are described in Table 1.

Table 1: Details of cinnamon processed slices' sample

Category	Source
Quigui traditional decoction pieces	Laboratory preparation
Chungui integrated decoction pieces	Laboratory preparation
Chungui traditional decoction pieces	Laboratory preparation
Chungui traditional decoction pieces	Laboratory preparation
Quigui traditional decoction pieces	Laboratory preparation
Quigui integrated decoction pieces	Laboratory preparation
Chungui integrated decoction pieces	Laboratory preparation
Quigui integrated decoction pieces	Laboratory preparation

Methods

Determination of cinnamaldehyde and cinnamic acid

The contents of cinnamaldehyde and cinnamic acid in cinnamon samples were dogged by a high-performance liquid chromatography (HPLC) method, which presented a good linear relationship between the peak area and the concentrations of cinnamaldehyde and cinnamic acid in the range of 0.0169–0.1180 mg/mL and 0.0775–1.24 g/mL. The results of precision, repeatability, stability, and recovery were approved with the provisions in the Chinese Pharmacopeia 2020.

Each of the cinnamon sample powder was precisely weighed for preparing the sample solutions according to the earlier method and filtered through 0.45 μm microporous filter membranes. After filtration, the HPLC analysis was carried out to compute the cinnamaldehyde and cinnamic acid contents in each sample.

Determination of volatile oil

The content of volatile oil in the cinnamon sample was dogged according to the volatile oil's determination method (2020 general edition of the Chinese Pharmacopeia, part 4, general rule 2204).

Determination of extract

The alcohol-soluble and water-soluble contents of the cinnamon samples were determined following the hot-extraction method, recommended by the 2020 Chinese Pharmacopeia General Principle 2201 Water-soluble Extracts.

The E-nose (Heracles II ultra-fast gas-phase electronic nose) system comprised a sampling device, an air generator device, a detector unit, encompassing a sensor array, an HS-100 automatic sampler (Alpha Mos, France), and a data processing software (Alpha Soft, Version 2012.46). Heracles II ultra-fast gas-phase electronic nose covers two chromatographic columns with different polarities, MXT-5 and MXT-1701 (length 10 m, column diameter 18 μm), to detached headspace-treated samples.

Before operating the E-nose system, the detection parameters should be designated. In this study, the sample weighing, injection volume, and shaking time of the samples were examined by the single-factor identification method and the preliminary identification method of cinnamon was recognized using ultra-fast gas-phase electronic nose technology. Figures 1-3 display the variations in the different signal intensities of the electronic nose, comprising symmetrical sample weighing, injection volume, and shaking time. Figure 1 illustrates that for 0.5 g of the sample, the signal intensity of each peak reaches the maximum value. Figure 2 shows that the sample signal intensity and peak area are saturated when the injection volume is 1500 μL; Figure 3 shows no noteworthy change in the chromatographic peak after shaking for 10 min. Therefore, 0.5 g of sample weight, 1500 μL of injection volume, and 10 min of shaking time were designated as experimental conditions in this study. The details are described in Table 2.

A discriminant model was recognized under the above experimental conditions, 14 batches of different cinnamon samples were composed for analysis and two chromatographic columns were employed to establish a discriminant factor analysis (DFA) discriminant model. The DFA discriminant model [Figure 4] displays that the discriminant factor 1 is 70.844%, the discriminant factor 2 is 29.156%, and the sum of the two discriminant factors becomes 100%. The discriminant

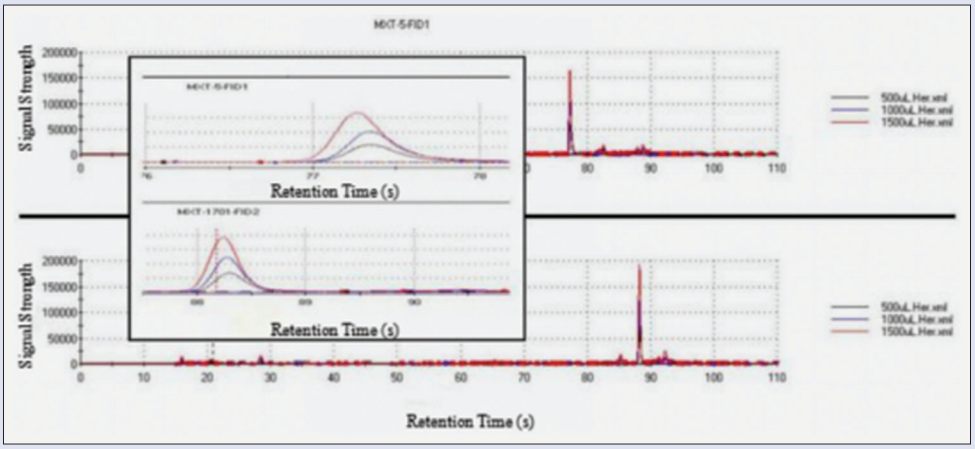

Figure 1: Chromatograms for different sample weights

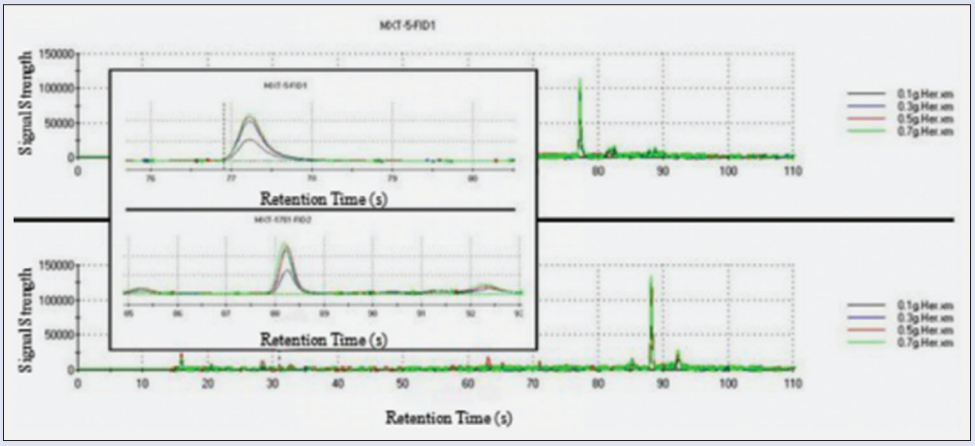

Figure 2: Chromatograms for different sample injection volumes

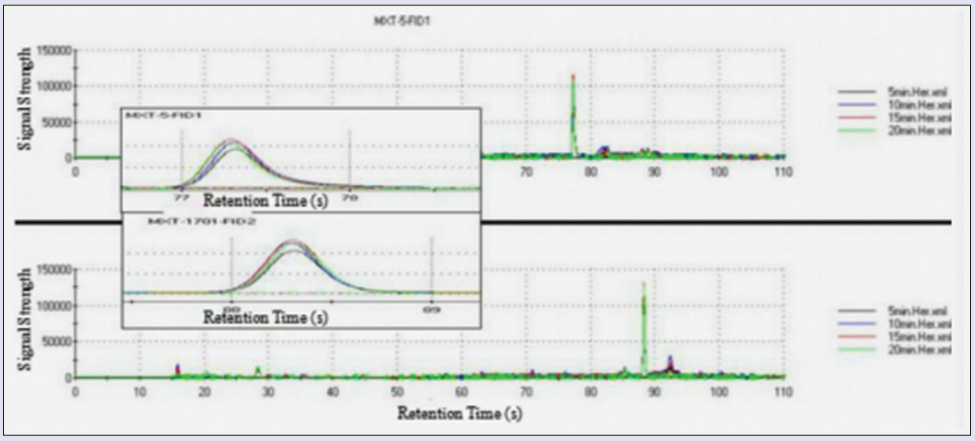

Figure 3: Chromatograms for different shaking time

results between the samples are very decent. All the samples have been established and the identification values are 100%, signifying certain differences in the smell of different samples of cinnamon. Under this experimental condition, the E-nose system technology can effectively differentiate diverse cinnamon samples.

The samples of cinnamon processed pieces (No. 1–8) were exclusively crumpled, passed through a No. 3 sieve, poured into empty bottles, and wrapped for future use. The E-nose system was employed to analyze the above samples. Using two hydrogen flame detectors, the chromatogram and radar map of the cinnamon samples were found

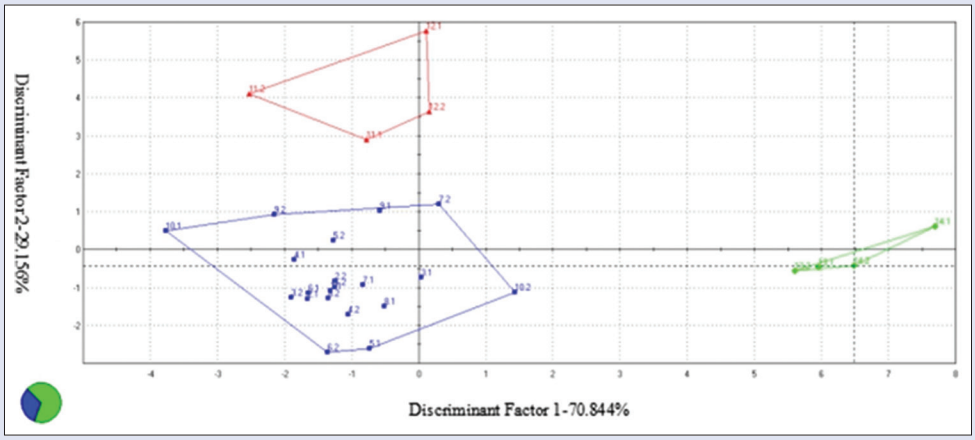

Figure 4: Discriminant factor analysis scores plots for recognizing cinnamon decoction pieces according to E-nose

from two chromatographic columns and the relative peak areas of the samples were verified.

Caenorhabditis elegans

Extraction of volatile oil from cinnamon

About 300 mL of water was positioned in a 1000 mL round-bottom flask and about 12.50 g of cinnamon powder (through No. 3 sieve) was added into the flask, which was linked to the volatile oil measuring device. Then, water was added to fill the scale until it overflew into the flask and the condenser tube was allied. Water was heated to boil, keeping the middle of the condensing tube in the cooling state. After 60 min, heating was stopped and the liquid was set aside for more than 15 min. The oil layer collected was the cinnamon volatile oil.

Heat treatment experiment

After culturing at 20°C for 3 days, the nematodes were moved to a new blank nematode growth medium (NGM) agar plate containing volatile oil from cinnamon decoction pieces and an agar plate containing DMSO°NGM, to treat for 48 h. Then, those plates were incubated at 36°C to record the number of dead nematodes per hour. Finally, the survival rate was planned.

Oxidative stress experiment

Oxidative damage was carried out using a 10 mM paraquat solution. The nematodes, incubated at 20°C for 5 days, were collected and engrossed in a 10 mM paraquat solution. The nematodes were collected after 4 h and transferred to the prepared NGM culture plates (50 pieces per plate and 4 plates per group), comprising the test compound. They were cultured at 20°C and the number of nematode deaths was logged every 4 h. Finally, the survival rate was designed.

Statistical processing

Firstly, based on the correlation between each trait indicator of cinnamon processed pieces, a three-level complete evaluation model was recognized to form the target layer A, criteria layer B, subcriteria layer C, and project hierarchy D [Figure 5]. The goal (quality evaluation of the processed cinnamon pieces) is distinct by the first level of the hierarchy. The second level is the criteria layer which is the effect factor related to the quality of the processed cinnamon pieces and the secondary criteria (such as the content of cinnamic acid) is at the third level. The substitute is on the fourth level, which is the unlike qualities of the processed cinnamon pieces.

Table 2: Sample preparation parameters for the Heracles E-nose analysis

Parameter	Headspace analysis
Headspace	
Bottle	20 ml
Sample volume	0.5 g
Shaking time	15 min
Shaking temperature	40°C
Injection	
Injection volume	1500 µl
Injection speed	125 µl/s
Inlet temperature	200°C
Injection duration	24 s
Traps	
The initial temperature	40°C
Diversion	10 ml/min
Capture duration	50 s
Final temperature	240°C
Column temperature	
Initial temperature	50°C (2 s)
Program warming	3.0°C/s-250°C (21 s)
Collection time	110 s
Detector	
Detector temperature	260°C
FID gain	12

FID: Flame ionization detector

Second, the relative prominence of the each factor at the same level was compared and a comparison matrix was created to determine the weight of each index's impact on the quality evaluation. In the method, defined by T. L. Saaty, the relative importance of the two factors, i and j, was articulated by the ratio of 1:9 [Table 3], i.e., when a factor C at the previous level is employed as a comparison criterion, a comparison scale (a_{ij}) can be used to definite the relative importance of the i^{th} factor and j^{th} factor in the next level. B1-Bn are the set of rudiments in the pairwise comparison matrix A and a_{ij} is the quantitative result of the pair of elements Ci and Cj, which forms an n × n comparison matrix A, as follows. From the comparison judgment matrix A in the comparison of n factors, we only want to make n (n-1)/2 pairwise comparisons, but the n (n-1)/2 times break matrix A must meet consistency. At this time, the comparison matrix has the ensuing characteristics: $A_{ij} = 1$, $a_{ji} = \frac{1}{a_{ij}}$, $a_{ij} \neq 0$.

$$A = \begin{pmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{pmatrix}.$$

Third, the eigenvalues and eigenvectors were considered. When the pairwise comparison matrix A is a uniform matrix, the normalized eigenvector W of the eigenvalue λ_{max} = n of A is a weight vector, i.e., the weight vector gratifies AW = λ_{max}W and $\sum_{i=1}^{n} w_i = 1$ as follows:

$$AW = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = \lambda_{max} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = \lambda_{max} w,$$

Finally, the steadiness of the method was squared. The consistency index (CI) and the consistency ratio (CR) proces the consistency of paired comparison and the calculation method $CI = \frac{\lambda_{max} - n}{n-1}$ is and, $CR = \frac{CI}{RI}$ where RI is the random CI whose value for computation is presented in Table 4. When CR < 0.1, it is measured that the discrepancy degree of A is within the allowed range. In this case, the normalized eigenvector W of the pairwise comparison matrix A can be viewed as the weight vector. Table 5 displays the pairwise comparison matrix, CI, and eigenvalue at each level. All CR values are <0.1 and all matrices can be measured to be reliable.

Table 3: Nine-Point Scale values used in pair-wise comparison

Values	Definition
1	Both indicators are equally important
3	One indicator is moderately important than the other
5	One indicator is strongly more important than the other
7	One indicator is very strongly important than the other
9	One indicator is extremely strongly important than the other
2, 4, 6, 8	The intermediate value of two adjacent degrees
Reciprocal	If "j" is compared with "I," then $a_{ji}=1/a_{ij}$

RESULTS

Sample data set results

The substances of cinnamic acid, cinnamaldehyde, volatile oil, and extracts were dogged according to the method, termed in 2.2; we verified the response of the electronic nose to measure the odor of the cinnamon processed pieces according to the method, labeled in 2.3; and the survival rate of the volatile oil from the cinnamon processed pieces to *C. elegans* was restrained according to the method, defined in 2.4. The details are revealed in Table 5. Since the dimensions were not even among the indicators, a dimensionless process was performed on the original data. From the viewpoint of quality research, the higher the index content was, the better was the quality and it was observed as a positive index.[9] Otherwise, it was viewed as a reverse indicator. In this study, all of the eight indicators were optimistic indicators and the dimensionless matrix Z_{ij} was considered according to the calculation formula ($Z_{ij} = \frac{Y_{ij}}{Y_i max}$). The details are exposed in Table 6.

Analytic Hierarchy Process Analysis Results

The overall score (S) was employed as the comprehensive appraisal value of the cinnamon decoction samples and the relative index value (CW) of each alternative in the scheme layer of Table 5 was combined with the weight (W) of each grade element. Usually, a

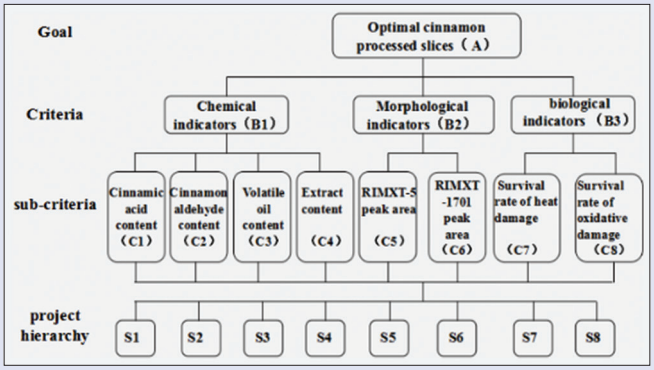

Figure 5: Hierarchical structure model of comprehensive evaluation factors for different cinnamon decoction pieces

Table 4: Average random consistency index RI table

	Matrix order								
	1	2	3	4	5	6	7	8	9
Random consistency index	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Table 5: Values of indicators for eight batches of cinnamon decoction pieces

Component factor				Character factor		Bio-active factor	
Cinnamic aldehyde content (%)	Cinnamic acid content (%)	Volatile oil content (%)	Extract content (%)	RIMXT-5 peak area	RIMXT-1701 peak area	Survival rate of *C. elegans* under heat damage (%)	Survival rate of *C. elegans* under oxidative damage (%)
2.41	1.76	0.113	14.68	30.32	25.91	10	5.0
3.92	4.31	0.079	14.84	29.43	28.19	15.4	7.6
3.2	2.92	0.07	15.21	29.85	25.41	11.2	5.0
3.58	2.76	0.045	15.18	25.61	22.24	10.9	7.5
2.92	2.48	0.048	14.54	27.19	23.93	10	5.0
3.29	3.16	0.055	18.88	26.67	23.78	10.8	5.0
3.91	3.91	0.086	21.42	26.11	23.47	14.3	8.2
3.23	3.2	0.052	18.37	27	24.88	10.6	6.4

C. elegans: Caenorhabditis elegans; RIMXT:Gas chromatographic column

higher comprehensive value imitates a *better quality* for the cinnamon processed pieces. The higher was the S value of the eight varieties; the better was the quality of the cinnamon processed pieces. Table 7 designates that B-level trait index weight vector is $W^{(2)}$ = (0.623, 0.240 and 0.137). The weight vectors of subcriteria C to B1, B2, and B3 are W (31) = (0.534, 0.144, 0.68, and 0.054), W (32) = (0.5 and 0.5) and W (33) = (0.5 and 0.5), respectively. By multiplying the standardized value of the indicator data of the cinnamon decoction samples by the weight of each factor, the complete score of each cinnamon variety was considered and the ranking of the cinnamon decoction samples' varieties was ranked by the score [Table 7].

DISCUSSION

This study recognized a model for widely evaluating the quality of the cinnamon decoction samples after weighting multi-index data based on AHP.[10,11] Table 7 displays that the CR of the AHP evaluation model is located between 0.000 and 0.061, specifying that the comparison judgment matrix at all levels in the evaluation model is reliable and the method model can be improved to assess and discriminate the quality of the cinnamon decoction samples.

Table 8 displays that the top qualities of S2 and S7 are the integration of the primary handling and the processing of the cinnamon decoction samples, representing that the integration is helpful for the quality control of the cinnamon decoction samples. The reason for the analysis may be: the integration flinches at the source of the medicinal agents, the source and origin of the medicinal agents can be outlined, and the standardization of the cultivation and the treating of the medicinal materials can be reinforced. Second, cinnamon assimilated processing decreases cross-repetition and intermediate storage of the processing and the dispensation of medicinal agents, which lessens the loss of both the effective ingredients and human resources, diminishes costs, and recovers the production efficiency. Furthermore, the results display that the complete score of cinnamon during the harvest period (spring) is higher than that during the fall period, signifying that the farmers must harvest cinnamon during spring. Due to this reason, bark herbs are usually harvested during spring and summer when the plant cultivates well and the plant is full of slurry and easy to peel.[12,13] Table 7 demonstrates that the weight coefficient of cinnamaldehyde is the biggest, specifying that it significantly predisposed the quality of cinnamon decoction samples, followed by volatile oil, signifying that the active ingredient, stipulated in the 2020 edition of Chinese Pharmacopeia, is an important indicator for the quality estimation of the cinnamon decoction samples. As shown in Table 6, no important difference can be detected in the content of cinnamic aldehyde among the cinnamon decoction samples. If the only content of cinnamic aldehyde is employed as standard, the quality of cinnamon cannot be obviously notable, indicating that other measurement indicators are also cinnamic aldehyde, also move the quality of cinnamon. Currently, when assessing the quality of cinnamon and its decoction samples, the content and safety of the index components, stated by the Pharmacopeia, are often employed as indicators and other active ingredients are often overlooked. The extract as a quality control item, approved by the Pharmacopeia, is also an indicator for evaluating the quality of the decoction samples,[14] the purpose of the extract is not only in line with the characteristics of the complex system of TCM but also near to the clinic. Therefore, this article enhances the measurement results of the extract to assess the quality of decoction pieces.

Table 6: The dimensionless matrix of each index value of eight batches of the cinnamon decoction samples (Z_{ij})

C1	C2	C3	C4	C5	C6	C7	C8
0.615	0.408	1.000	0.685	1.000	0.919	0.649	0.610
1.000	1.000	0.699	0.693	0.971	1.000	1.000	0.927
0.816	0.677	0.619	0.710	0.984	0.901	0.727	0.610
0.913	0.640	0.398	0.709	0.845	0.789	0.708	0.915
0.745	0.575	0.425	0.679	0.897	0.849	0.649	0.610
0.839	0.733	0.487	0.881	0.880	0.844	0.701	0.610
0.997	0.907	0.761	1.000	0.861	0.833	0.929	1.000
0.824	0.742	0.460	0.858	0.891	0.883	0.688	0.780

Table 7: Judgment matrix and weight, maximum eigenvalue, and consistency ratio

Project	Judgment matrix				Weights (W)	Eigenvalues (λ_{max})	CR
A-Bi	B1	B2	B3				
B1	1	2	1/3		0.240	3.0197	0.017
B2	1/2	1	1/4		0.137		
B3	3	4	1		0.623		
B1-Ci	C1	C2	C3	C4			
C1	1	4	3	7	0.534	4.1734	0.061
C2	1/4	1	1/3	4	0.144		
C3	1/3	3	1	5	0.268		
C4	1/7	1/4	1/5	1	0.054		
B2-Ci	C5	C6					
C5	1	1			0.500	3.000	0.00
C6	1	1			0.500		
B3-Ci	C7	C8					
C7	1	1			0.500	3.000	0.00
C8	1	1			0.500		

CR: Consistency ratio

Table 8: Analytic hierarchy process comprehensive score and ranking

Variety	Synthesis score	Synthetical sequencing
Traditional processing Quigui slices	68.9746	7
Original processing integrated Chungui slices	95.1935	1
Traditional processing Chungui slices	72.2589	5
Traditional processing Chungui slices	791410	3
Traditional processing Quigui slices	66.3267	8
Original processing integrated Quigui slices	70.2071	6
Original processing integrated Chungui slices	93.7951	2
Original processing integrated Quigui slices	75.0755	4

CONCLUSION

Based on the analytical process in the pharmacopeia, AHP efficiently combines the chemical indicators, character indicators, and biological activity of cinnamon decoction samples and empirically weights each index to discriminate the significant degree and this study can give a precise quantification value and more widely and objectively assess the quality of cinnamon decoction pieces. In this study, AHP was pragmatic to measure the quality of TCM decoction pieces in combination with chemical detection, character detection, and biological detection of the trinity of the multivariate testing method. It can overawed the inadequacies of the conventional methods to assess the quality of the varieties independent of each other with single or several main traits and quantitatively, comprehensively, and objectively deliberate the impact of multiple traits on the pros and cons of the variety and more realize the objectivity of the evaluation. For accomplishing reliable results, AHP

articulates the complex quality evaluation of the decoction pieces in an orderly hierarchical structure and AHP widely studies those qualitative and quantitative factors, which are not pure and difficult to quantify; it also instinctively determines the importance of each factor in the evaluation system by weakening the subjective and objective impact on the analytical results. Further, it obtains weight values and checks the reliability of judgment through the pairwise comparison of factors and ranks the quality of decoction samples by objective judgment. This study delivers a new method and idea for the assessment of Chinese herbal decoction pieces.

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Conflicts of interest

There are no conflicts of interest.

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