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PRELIMINARY RESEARCH ON ESTABLISHING THE QUALITY STANDARDS FOR WINE-PROCESSED *RADIX ANGELICAE SINENSIS*

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Summary

This study aimed to establish preliminary quality standards for wine-processed *Radix Angelicae sinensis*. Quality parameters including organoleptic characteristics, qualitative identification, moisture content, total ash, quantitative determination, and extractive values were evaluated to support the establishment of quality standards for *Radix Angelicae sinensis* and the revision of its monograph in the Vietnamese Pharmacopoeia. The established quality specifications require organoleptic consistency, with moisture content not exceeding 15%, total ash not exceeding 7%, acid-insoluble ash not exceeding 2%, and an extractive value not less than 40%. Qualitative identification by thin-layer chromatography (TLC) confirmed the presence of ferulic acid and *Z*-ligustilide using the solvent system cyclohexane–dichloromethane–ethyl acetate–formic acid (4:1:1:0.1, v/v/v/v). Furthermore, quantitative analysis indicated that the contents of ferulic acid and *Z*-ligustilide in the processed material should not be less than 0.05% and 0.6%, respectively. These results provide a comprehensive and scientific basis for the quality control of wine-processed *Radix Angelica sinensis*.

Keywords: *Angelicae sinensis; Ferulic acid; Z-ligustilide.*

1. Introduction

Angelicae sinensis (Oliv.) Diels, belonging to the family Apiaceae, is a valuable medicinal plant widely used in Traditional Chinese Medicine. It is particularly employed for the treatment of gynecological disorders, including menstrual irregularities, menopausal symptoms, and anemia, and is also used as a blood-tonifying agent [1]. The chemical composition of *A. sinensis* is diverse and includes phthalide compounds such as ligustilide, butylphthalide, and senkyunolide A; phthalide dimers; organic acids and their esters, including ferulic acid and coniferyl ferulate; as well as polyacetylenes, vitamins, and amino acids [2],[3]. Among these constituents, *Z*-ligustilide is thermally unstable and readily decomposes, whereas *Z*-butylidenephthalide and ferulic acid are considered to be among the most biologically active components of *A. sinensis* [4]. Due to its rich chemical composition, *A. sinensis* has been reported to possess various pharmacological activities, including hematopoietic regulatory, anti-inflammatory, anti-rheumatic, sedative, neuroprotective, antioxidant, antitumor, and anti-allergic effects. Consequently, it has been widely used in the management of several conditions such as rheumatoid arthritis, knee osteoarthritis, lumbar disc herniation, ankylosing spondylitis, headache, post-stroke hemiplegia, Alzheimer's disease, and cardiac arrhythmia [3].

In recent years, traditional medicines have attracted increasing attention and have become an important area of development. To enhance therapeutic efficacy and reduce potential toxicity, *Radix A. sinensis* is commonly processed using the wine-processing method (alcohol steaming or frying) [5]. However, processing may alter the chemical composition as well as certain quality parameters of the crude drug [6]. In Vietnam, although National Standards (TCVN) have been established for wine-processed *Radix A. sinensis* (TCVN 11776-10:2017 – Part 10: *Radix Angelicae sinensis Preparata*), these specifications focus primarily on basic criteria while lacking qualitative and quantitative standards for key active marker compounds. Furthermore, official monographs for this processed form remain absent from the Vietnamese Pharmacopoeia VI. Consequently, the comprehensive management and quality control of this medicinal material in the market remain limited. Accordingly, this study aimed to develop quality standards for wine-processed *Radix A. sinensis* derived from crude materials complying with the Vietnamese Pharmacopoeia VI, providing a basis for the quality evaluation of this processed material in the market.

2. Materials and Methods

2.1. Plant materials, chemicals and equipment

Plant materials

The crude *A. sinensis* used in this study was supplied by Indochina Medicinal Materials Joint Stock Company and complied with the requirements of the Vietnamese Pharmacopoeia VI. Wine-processed *Radix A. sinensis* samples (ĐQCR1-6) were prepared from this crude material at the Center for Application of Science and Technology in Medicinal Materials, National Institute of Medicinal Materials, in accordance with Circular No. 30/2017/TT-BYT [5], which provides guidelines for the processing of traditional medicinal materials. Two commercial samples of wine-processed *A. sinensis* (ĐQTT1-2) were purchased from different traditional herbal medicine shops on Lan Ong Street, Hanoi.

Processing method: The crude roots were washed, drained, and sliced into pieces approximately 1–3 mm thick. About 1 kg of the sliced material was mixed thoroughly with 100 mL of 30 – 35% alcohol and allowed to macerate for 30 min with occasional stirring to ensure uniform absorption. The material was then stir-fried at 80°C for 40 min until dry, removed, cooled, and packaged [5].

The resulting wine-processed *Radix A. sinensis* (*Radix Angelicae sinensis praeparata*) was ground into coarse powder for subsequent analyses.

Chemicals and equipment:

All chemicals and solvents used were of analytical grade. Solvents (methanol, acetonitrile, ethyl acetate, cyclohexane, dichloromethane, formic acid, and acetic acid) for chromatographic analyses (TLC and HPLC) were obtained from Merck (or equivalent suppliers). Reference standards included ferulic acid (No. CFN92394, purity 99%) and *Z*-ligustilide (No. CFN99932, purity 99%) supplied by Chemfaces, China.

Ultrasonic bath (Sonorex), infrared moisture balance (Ohaus), analytical balance (Sartorius), HPLC system (Shimadzu; comprising LC-20AD pump, SIL-20C autosampler, CTO-20A column oven, and SPD-M20A DAD detector), Shimadzu C18 column (250 mm × 4.6 mm, 5 µm).

2.2. Methods

Quality standards for wine-processed *Radix A. sinensis* were established based on the general criteria specified in the Vietnamese Pharmacopoeia VI and the National Standard TCVN 11776-10:2017 – Part 10: *Radix Angelicae sinensis Preparata*. The evaluated parameters for the processed herbal material included description, moisture content, total ash, identification, and quantitative determination.

- *Description:* The crude drug was evaluated by organoleptic examination, including observations of shape, texture, color, odor, and taste.

- *Powder:* The powdered sample (sieved through No. 250) was mounted in water on a slide, covered with a coverslip, and examined under a light microscope.

- *Moisture content*: Determined by the gravimetric method according to the Vietnamese Pharmacopoeia VI, Appendix 9.6

- *Total ash*: Determined according to the Vietnamese Pharmacopoeia VI, Appendix 9.8.

- *Extractive values*: Determined according to the Vietnamese Pharmacopoeia VI, Appendix 12.10, using the hot extraction method with 96% ethanol as the extraction solvent.

- *Identification*: ferulic acid and *Z*-ligustilide were identified by thin-layer chromatography (TLC) [7],[8],[9].

Stationary phase: *Silica gel* 60 F_{254} (Merck);

Mobile phase: Cyclohexane–dichloromethane–ethyl acetate–formic acid (4:1:1:0.1, v/v/v/v).

Test solution: 4 g of the powdered material was mixed with 20 mL of 95% ethanol and allowed to macerate for 1 h with occasional shaking. The mixture was filtered, and the filtrate was evaporated to a volume of approximately 10 mL to yield the test solution.

Reference material solution: reference material solution was prepared using 4 g of reference *Radix A. sinensis* powder, subjected to the same

extraction procedure described for the test solution.

Blank sample: Methanol solution.

Reference solutions: Reference solutions were prepared by dissolving ferulic acid and Z-ligustilide standards in methanol to obtain solutions with a concentration of 1 mg/mL.

Procedure: 10 µL of each solution was separately applied to the TLC plate. After development, the plate was removed, dried at room temperature, and observed under ultraviolet light at 365 nm. The chromatogram of the test solution should exhibit spots with the same color and R_f values as those of ferulic acid and *Z*-ligustilide in the reference solution, and corresponding spots to those observed in the reference herbal material solution.

2.3. Determination of ferulic acid and Z-ligustilide by high-performance liquid chromatography (HPLC)

The contents of ferulic acid and *Z*-ligustilide in the sample solution were determined using high-performance liquid chromatography (HPLC), based on the methods described in the Vietnamese Pharmacopoeia VI, the Hong Kong Chinese Materia Medica Standards, and several published studies on the quantitative analysis of these compounds in *Angelicae* root [7-9]. Ferulic acid and *Z*-ligustilide were quantified using calibration curves constructed from standard solutions.

Chromatographic conditions

HPLC analysis was performed on a Shim-pack C18 reversed-phase column (250 mm × 4.6 mm, 5 µm). Detection was carried out using a photodiode array (PDA) detector at 322 nm. The column temperature was maintained at 40 °C. The injection volume was 10 µL, and the flow rate was 1.0 mL/min.

The mobile phase consisted of acetonitrile (A) and 1% acetic acid in water (B), using a gradient elution program as follows: 0–18 min, 19% A; 18–20 min, 19–60% A; 20–50 min, 60% A.

Sample preparation

Optimization of extraction conditions: To optimize ferulic acid and *Z*-ligustilide extraction from wine-processed *Radix A. sinensis* (sample ĐQCR2), a powdered sample (1.0 g) was extracted with 50 mL of solvent under varying conditions. The effects of extraction method (maceration, reflux, and ultrasound; 50% MeOH, 60 min), solvent concentration (water and 30–100% aqueous MeOH; reflux, 60 min), extraction time (20–140 min; reflux, 50% MeOH), and solid-to-solvent ratio (1:10–1:50 g/mL; reflux, 50% MeOH, 40 min) were systematically evaluated. All experiments were conducted in triplicate, and target compounds were quantified using HPLC [10].

Reference solution: Working standard solutions of ferulic acid and *Z*-ligustilide were prepared in methanol at concentrations of 10–500 µg/mL (10, 25, 50, 100, 200, 300, and 500 µg/mL). The content of each compound in the crude drug was calculated using the following equation:

$$\text{Content } (\mu g/g) = \frac{C \times V \times 100}{m \times (100-h)} \times 1000$$

Where: C: the concentration of ferulic acid or *Z*-ligustilide in the test solution (µg/mL);

V: the volume of the test solution (mL)

m: the mass of the sample (mg)

h: the moisture content of the sample (%).

The linear regression equations, slope significance, and statistical evaluation of the y-intercept were analyzed using IBM SPSS Statistics software. Student's t-test was applied at a 95% confidence level ($p > 0.05$) to verify that the intercept was not significantly different from zero.

3. Results and Discussion

3.1. Description of wine-processed Radix A. sinensis

The slices are irregular in shape, with a thickness ranging from 1 to 3 mm. The outer surface is light brown and exhibits numerous longitudinal wrinkles. The inner surface is dark brown with a tough texture. The material possesses a characteristic aroma, with a taste that is sweet, pungent, and slightly bitter.



Fig. 1. Wine-processed *A. sinensis* samples.

Zhang et al. conducted a comparative study on the color characteristics of raw *A. sinensis* (RAS), wine-washed *A. sinensis* (WAS), and wine stir-fried *A. sinensis* (WSAS) using spectrophotometric analysis. The results demonstrated a progressive change in color in the order of WAS > WSAS > RAS, indicating that processing with yellow rice wine led to a lighter appearance, with WAS exhibiting the lightest color among the samples.

In terms of sensory properties, RAS was characterized by a relatively irritating odor. This odor was noticeably reduced after processing with yellow rice wine (WAS and WSAS), accompanied by the characteristic aroma of the wine. Furthermore, although the aroma of WSAS was less intense than that of WAS, it exhibited a mild sweetness along with a distinctive roasted note [11].

3.2. Powder

As shown in **Fig. 2**, the microscopic analysis revealed key diagnostic characteristics typical of the sample powder: yellowish brown, with a characteristic aromatic odour. Microscopic examination shows numerous simple starch grains, fragments of parenchyma containing numerous starch grains, fragments of reticulate, pitted vessels, and cork fragments.

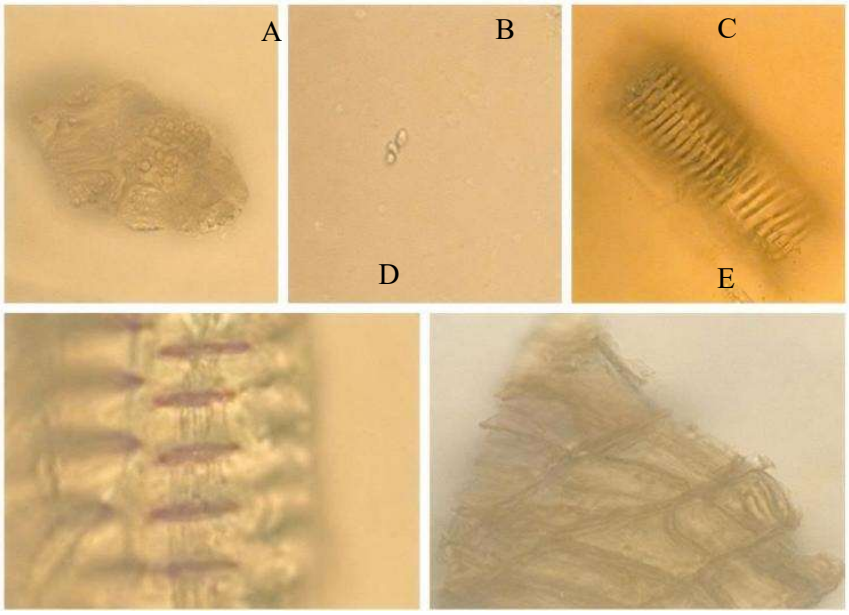


Fig. 2. Powder microscopic features: (A) parenchyma with starch grains, (B) simple starch grains, (C) reticulate vessel, (D) pitted vessel, (E) cork fragments (40x).

3.3. Moisture content, total ash, acid-insoluble ash and extractive values

The results for moisture content, ash values and extractive values of the wine-processed *Radix A. sinensis* samples are presented in the table below:

Table 1. Moisture content, ash values and extractive values of wine-processed *Radix A. sinensis* samples (*n=3*)

No.	Sample	Moisture content (%)	Total ash (%)	Acid-insoluble ash (%)	Extractive values (%)
1	DLĐQ	12.75 ± 0.01	4.48 ± 0.06	0.73 ± 0.11	43.58 ± 0.02
2	ĐQCR1	9.05 ± 0.04	4.44 ± 0.07	0.71 ± 0.06	45.48 ± 0.19
3	ĐQCR2	9.15 ± 0.12	4.51 ± 0.09	0.72 ± 0.08	46.18 ± 0.25
4	ĐQCR3	8.96 ± 0.08	4.41 ± 0.14	0.73 ± 0.12	44.75 ± 0.21
5	ĐQCR4	9.09 ± 0.09	4.50 ± 0.10	0.72 ± 0.15	45.44 ± 0.17
6	ĐQCR5	8.88 ± 0.15	4.40 ± 0.05	0.70 ± 0.09	44.58 ± 0.19
7	ĐQCR6	9.11 ± 0.10	4.42 ± 0.17	0.72 ± 0.05	46.34 ± 0.15

Compared to the crude raw material (DLĐQ), the wine-processed samples (ĐQCR1–6) exhibited a noticeable decrease in moisture content (from 12.75% to 8.88–9.15%) due to the drying effect during the stir-frying process. Conversely, the ethanol-soluble extractive values slightly increased (from 43.58% to 44.58–46.34%), which can be attributed to the enhanced solubility and extraction efficiency facilitated by the rice wine pretreatment. Total ash and acid-insoluble ash contents showed negligible changes across all processed batches (4.40–4.51% and 0.70–0.73%, respectively).

Overall, all wine-processed batches fully complied with the foundational quality criteria established in national standard TCVN 11776-10:2017 (moisture content not exceeding 15%, total ash not exceeding 7%, acid-insoluble ash not exceeding 2%, and extractive value not less than 40%). These baseline parameters provide a necessary foundation for establishing in-house quality specifications, which are further reinforced by the supplementary marker-based evaluation criteria in subsequent sections.

3.4. Qualitative analysis

Qualitative identification of ferulic acid and *Z*-ligustilide was carried out using thin-layer chromatography (TLC). The method was adapted from the monograph of *Radix A. sinensis* in the Chinese Pharmacopoeia (2020) and Vietnamese Pharmacopoeia VI (2026). The results are presented in **Fig. 3**.

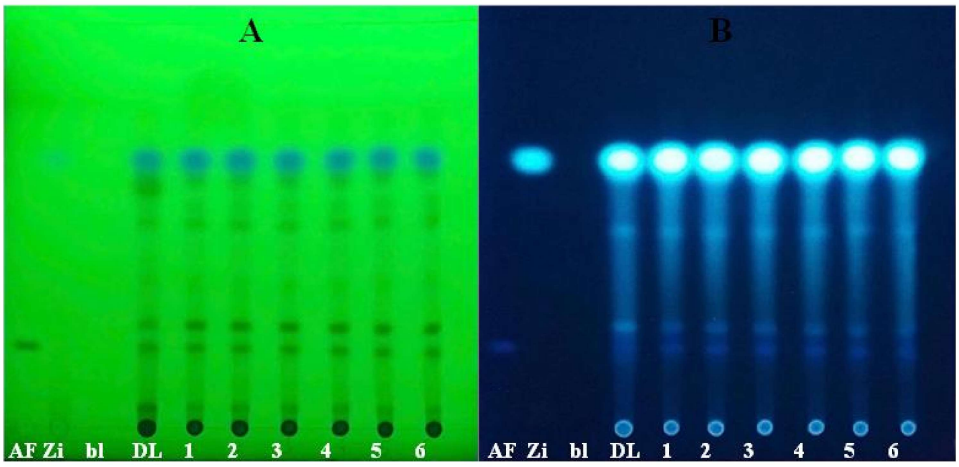


Fig. 3. TLC chromatograms for qualitative identification of crude and processed *A. sinensis*

a) Observation under UV light at 254 nm

b) Observation under UV light at 366 nm

(1–6): extracts of processed Radix A. sinensis. (DL): Reference herbal material solution (A. sinensis). (AF): Reference standard (ferulic acid). (Zi): Reference standard (Z-ligustilide). (bl): Methanol

Upon observation under UV light, the reference standard solution of ferulic acid, reference material solution, and all processed samples exhibited spots at 254 nm with a retention factor (R_f) value of 0.29. Similarly, the reference standard solution of *Z*-ligustilide, reference material solution, and all processed samples showed spots at 366 nm with an R_f value of 0.74. The chromatogram of the blank solution showed no interfering spots corresponding in color or R_f value to those observed in the test and reference material solutions. These TLC results confirm that the developed method meets the requirements for specificity.

As shown in **Fig. 3**, the method recommended in the *Radix A. sinensis* monograph of the Chinese Pharmacopoeia provided good separation efficiency. The chromatographic spots of the test samples were well-resolved and clearly visualized, confirming the presence of the target reference compounds in the wine-processed *Radix A. sinensis* samples [7].

3.5. Quantification of ferulic acid and Z-ligustilide by HPLC

3.5.1. Optimization of sample preparation conditions:

The extraction conditions for ferulic acid and *Z*-ligustilide from wine-processed *Radix A. sinensis* were systematically optimized based on single-factor experiments (**Fig. 4**).

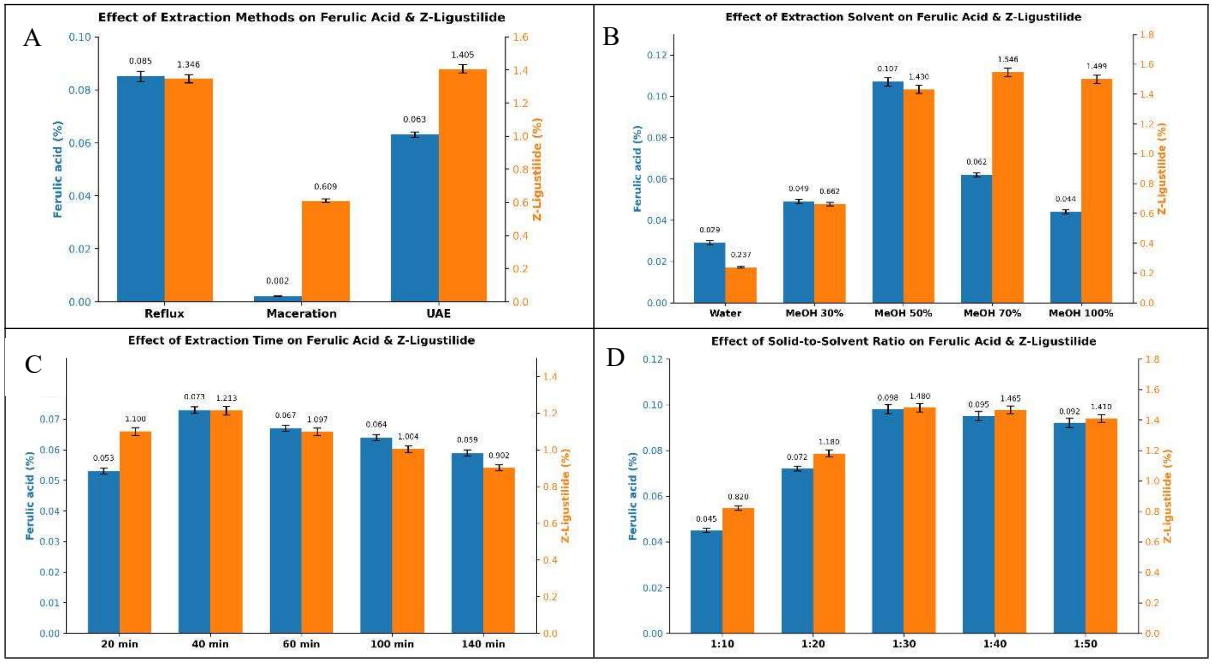


Fig. 4. Effects of extraction parameters on the contents of ferulic acid and *Z*-ligustilide in wine-processed *A. sinensis.*

Among the tested extraction methods (Fig. 4A), heat-reflux extraction achieved the highest recovery of ferulic acid (0.085%) and a high yield of *Z*-ligustilide (1.346%), outperforming maceration and ultrasound-assisted extraction. Regarding solvent concentration (Fig. 4B), 50% aqueous methanol provided the optimal balance, yielding peak ferulic acid (0.107%) and high *Z*-ligustilide (1.430%), whereas pure water or higher methanol concentrations lowered the recovery of at least one marker. Extraction time experiments (Fig. 4C) showed that 40 min yielded maximum compound contents (0.073% ferulic acid, 1.213% *Z*-ligustilide), beyond which thermal degradation occurred. Finally, increasing the solid-to-solvent ratio up to 1:30 g/mL (Fig. 4D) maximized yields (0.098% ferulic acid, 1.480% *Z*-ligustilide), with higher ratios providing no further benefit.

In conclusion, the optimal extraction parameters were determined as: heat-reflux extraction with 50% methanol, a solid-to-solvent ratio of 1:30 (g/mL), and an extraction time of 40 min.

3.5.2. Analytical method validation:

The established HPLC analytical conditions were applied for the quantification of ferulic acid and *Z*-ligustilide in the wine-processed *Radix A. sinensis* samples. The results are presented in **Fig. 5** and **Table 2**.

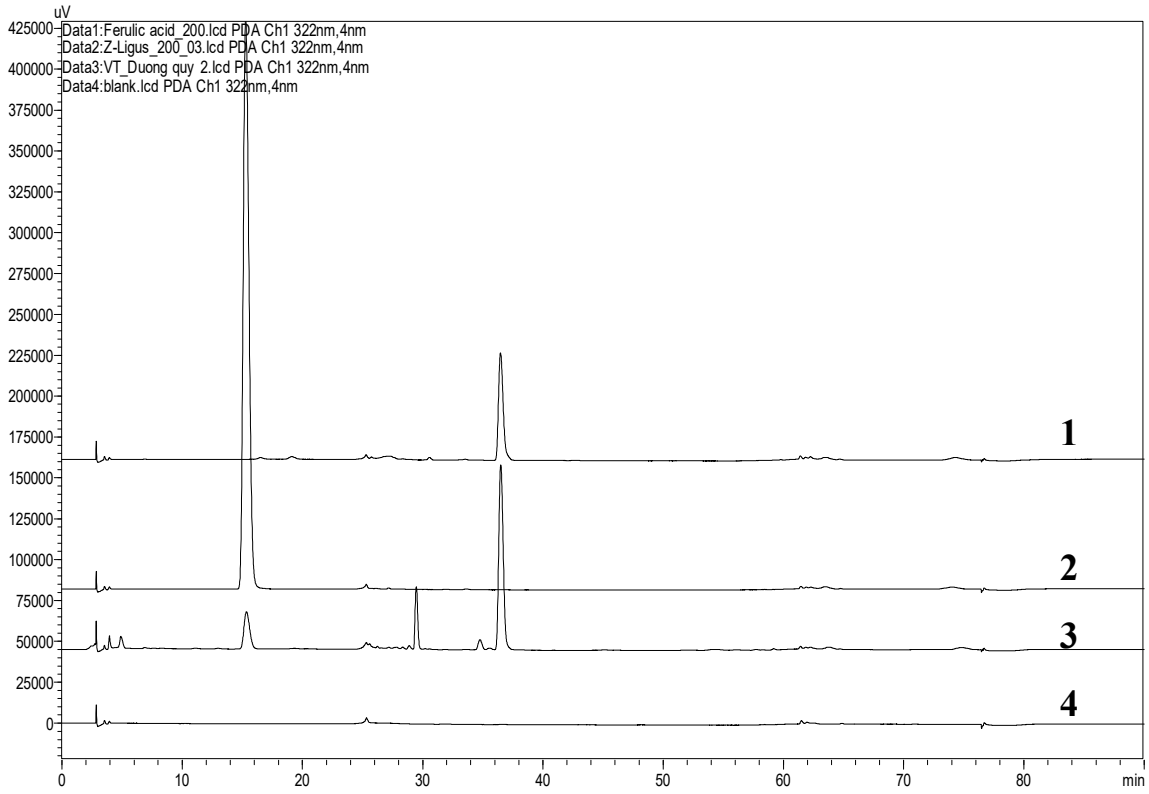


Fig. 5. HPLC chromatograms for the quantification of ferulic acid and *Z*-ligustilide in *Radix A. sinensis* sample *(1: Z-ligustilide, 2: ferulic acid, 3: Processed Radix A. sinensis, 4: Blank)*

The obtained results showed that the chromatographic peak of ferulic acid was sharp, symmetrical, and well-resolved from the sample matrix. These peak characteristics met the requirements for quantitative analysis.

The analytical method was validated in accordance with the guidelines of the International Council for Harmonisation (ICH) and AOAC International [12],[13].

Table 2. HPLC–DAD method validation for ferulic acid and *Z*-ligustilide in processed *Radix A.sinensis*

No.	Validation characteristics	Experiment	Results	
			Method for analyzing ferulic acid	**Method for analyzing *Z*-ligustilide**
1	System Suitability	Repeat analysis of the standard sample 6 times on the HPLC system	RSD (t_R)= 0.085% RSD (S) = 0.785%	RSD (t_R) = 0.042% RSD (S) = 0.903%
2	Selectivity (Specificity)	Analysis of blank sample (Methanol), standard sample, and test sample	High specificity t_R (AF) = 15.1	High specificity t_R (*Z*-li) = 36.4
3	Linearity*	Analysis of standard solutions of different concentrations	Linear range: 10 - 300 µg/mL Calibration curve: $y = 55629x + 96558$ R^2=0.999; x is the concentration of ferulic acid (µg/mL); y is the peak area (mAU.s)	Linear range: 10 - 500 µg/mL Calibration curve: $y = 9056.2x + 17291$ R^2=0.998; x is the concentration of *Z*-ligustilide (µg/mL); y is the peak area (mAU.s)
4	Precision	Repeat analysis of a test sample within a day and on different days (6 times/day).	RSD (Content % AF) = 1.83%	RSD (Content % *Z*-li) = 2.08%

No.	Validation characteristics	Experiment	Results	
			Method for analyzing ferulic acid	Method for analyzing *Z*-ligustilide
		The concentrations of ferulic acid and Z-ligustilide in standard solution were 49.74 and 84.72 µg/mL, respectively.		
5	Accuracy	Standard addition method (The accuracy was evaluated by adding standards to the sample at 3 levels: 80%, 100%, and 120%). The concentrations of ferulic acid and *Z*-ligustilide in the wine-processed *Radix A. sinensis* sample were 49.74 and 84.72 µg/mL, respectively.	Recovery rate (%) = 101.7% (range: 98.24 – 105.18%)	Recovery rate (%) = 100.3% (range: 98.02 – 101.52%)
6	LOD	Determined based on the signal-to-noise ratio (S/N) of test sample.	Conc (µg/mL): 0.02 Content (%): 0.00012	Conc (µg/mL): 0.21 Content (%): 0.00117
7	LOQ	Determined based on the signal-to-noise ratio (S/N) of test sample.	Conc (µg/mL): 0.1 Content (%): 0.00059	Conc (µg/mL): 0.67 Content (%): 0.00390

** The regression equations are statistically significant ($p < 0.05$). The intercept (b) is not statistically significant ($p > 0.05$)*

3.5.3. Quantification of active markers in wine-processed *A. sinensis:*

The quantitative results of ferulic acid and *Z*-ligustilide in crude (DLĐQ) and wine-processed *Radix A. sinensis* samples (ĐQCR1-6) are summarized in Table 3.

Table 3. Contents of ferulic acid and *Z*-ligustilide in selected crude **(**DLĐQ**)** and processed *A. sinensis* samples (n = 3)

No.	Sample	Ferulic acid (%)	*Z*-Ligustilide (%)
1	DLĐQ	0.106 ± 0.002	1.806 ± 0.002
2	ĐQCR1	0.071 ± 0.003	1.597 ± 0.004
3	ĐQCR2	0.070 ± 0.002	1.513 ± 0.003
4	ĐQCR3	0.081 ± 0.002	1.518 ± 0.003
5	ĐQCR4	0.073± 0.003	1.675 ± 0.003
6	ĐQCR5	0.080 ± 0.001	1.763 ± 0.002
7	ĐQCR6	0.071 ± 0.002	1.532 ± 0.003

As summarized in **Table 3**, wine processing notably reduced the contents of both ferulic acid and *Z*-ligustilide from 0.106% and 1.806% in crude *Radix A. sinensis* (DLĐQ) to 0.070–0.081% and 1.513–1.763% across processed batches (ĐQCR1–6), respectively.

This reduction is attributed to the thermal instability of ferulic acid and phthalide compounds—such as *Z*-ligustilide—with *Z*-ligustilide also being a volatile component prone to loss during thermal processing [14], [15]. These findings align with previous studies by Zhang et al., which compared raw (RAS), wine-washed (WAS), and wine stir-fried *A. sinensis* (WSAS), showing that the contents of ferulic acid and *Z*-ligustilide consistently decreased after processing [11].

While the Vietnamese Pharmacopoeia VI and Chinese Pharmacopoeia (2020) require at least 0.05% ferulic acid for raw *Radix A. sinensis*, and the Hong Kong Materia Medica Standards specify a minimum of 0.6% *Z*-ligustilide, these standards for wine-processed materials are notably absent from current monographs (including national standard TCVN 11776-10:2017). Based on the experimental results, quality control thresholds of not less than 0.05% for ferulic acid and not less than 0.6% for *Z*-ligustilide are recommended for wine-processed *A. sinensis*.

3.5.4. Application to commercial wine-processed *A. sinensis* samples:

To evaluate the practical applicability of the established quality standards, 02 commercial wine-processed *Radix A. sinensis* samples purchased from the market were analyzed using the analytical methods described in sections 2.2 and 2.3. The contents of ferulic acid and *Z*-ligustilide were quantified and compared against the proposed quality criteria, as summarized in **Table 4** and **Figs. 6-7.**

Table 4. Evaluation results of commercial wine-processed *Radix A. sinensis* samples (*AF: ferulic acid; Z-li: Z-ligustilide)*

No.	Specifications	Acceptance criteria	ĐQTT1	ĐQTT2
1	Description		Complies	Complies
2	Moisture content (%)	Not more than 15.0%	10.25 ± 0.02	12.36 ± 0.08
3	Total ash (%)	Not more than 7.0%	5.19 ± 0.05	4.56 ± 0.01
4	Acid-insoluble ash (%)	Not more than 2.0%	1.04 ± 0.02	1.25 ± 0.06
5	Extractive value (%)	Not less than 40.0%	42.28 ± 0.07	45.87 ± 0.11
6	Contents of ferulic acid and *Z*-ligustilide (%)	Not less than 0.05% for ferulic acid and 0.6% for *Z*-ligustilide	AF: 0.069 ± 0.003 Z-li: 1.501 ± 0.10	AF: 0.053 ± 0.008 Z-li: 1.624 ± 0.02



ĐQTT1 **ĐQTT2**

Fig. 6. Appearance of commercial wine-processed *Radix A. sinensis* samples

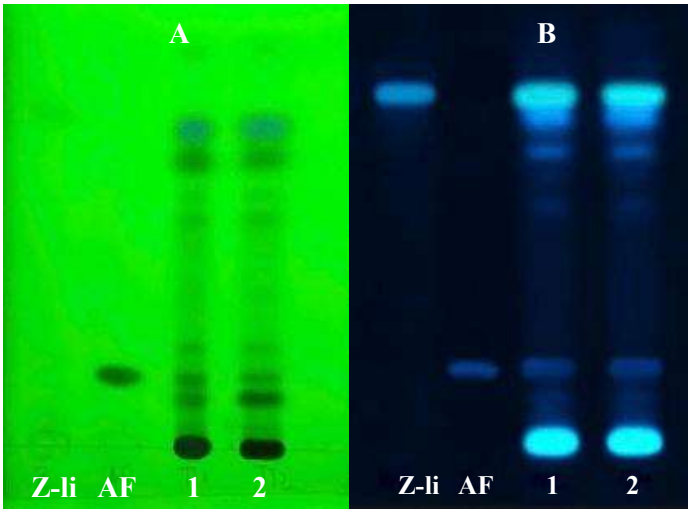


Fig. 7. TLC chromatograms for qualitative identification of ferulic acid and *Z*-ligustilide in commercial wine-processed *Radix A. sinensis* samples

a) Observation under UV light at 254 nm

b) Observation under UV light at 366 nm

(*AF: ferulic acid; Z-li: Z-ligustilide; 1–2: commercial samples ĐQTT1–2*)

Based on the obtained results, all commercial wine-processed *Radix A. sinensis* samples met the specifications outlined in the TCVN 11776-10:2017 monograph and the proposed quality standards. Notably, the quantitative evaluation showed that the contents of ferulic acid and *Z*-ligustilide complied with the proposed thresholds of not less than 0.05% for ferulic acid and not less than 0.6% for *Z*-ligustilide. These limits were established with direct reference to the current pharmacopoeial standards for crude *A. sinensis*, providing a pragmatic baseline for quality control of the processed drug.

In addition, the inclusion of additional characteristic markers, such as (*E*)-ligustilide, 3-butylidenephthalide, and senkyunolide A, is proposed to further elucidate the differences between crude and processed materials, thereby contributing to the development of more robust and precise quality standards.

4. Conclusion

Quality specifications for wine-processed *A. sinensis* (*Radix Angelicae sinensis Preparata*) were established, highlighting a novel TLC identification method using a cyclohexane–dichloromethane–ethyl acetate–formic acid (4:1:1:0.1, v/v/v/v) solvent system, alongside proposed quantitative limits of not less than 0.05% for ferulic acid and 0.6% for *Z*-ligustilide. Additionally, general quality criteria were defined, including organoleptic characteristics, powder, moisture content not exceeding 15%, total ash not exceeding 7%, acid-insoluble ash not exceeding 2%, and extractive value not less than 40%.

These preliminary findings from six batches (ĐQCR1–6) prepared from a single crude lot establish an initial framework for quality evaluation. Expanding sample sizes across multiple industrial lots will be required to validate and implement official standards for wine-processed *A. sinensis*.

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