We investigated the effect of steaming time on *Cistanche deserticola* Y. C. Ma slices by analyzing levels of bioactive compounds, antioxidant activity, and weight loss compared with fresh, directly oven-dried, and blanched samples. Fresh samples had extremely low levels of phenylethanoid glycosides and antioxidant activity. Lower levels of weight loss and higher amounts of soluble sugars, polysaccharides, and dilute ethanol-soluble extracts were found when the slices were steamed rather than blanched. Slices steamed for 5 and 7 min contained significantly (p≤0.05) higher amounts of acteoside, isoacteoside, and 2′-acetylaceoside than directly oven-dried samples. However, soluble sugars and dilute ethanol-soluble extracts decreased gradually throughout the steaming process. The concentration of polysaccharides fluctuated during the steaming process. The steaming time had a consistent effect on antioxidant properties evaluated by oxygen radical absorbance capacity (ORAC), 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity (DPPH) and ferric reducing antioxidant property (FRAP), showing a significant increase and reaching 108.62, 23.08, and 11.68 micromoles Trolox per mass of fresh slice (μmol TE/g FW), respectively. The present results suggest that fresh-cut *C. deserticola* can be subjected to approximately 5–7 min of steaming to improve phenylethanoid glycoside levels and antioxidant activity, while still preserving the amounts of soluble sugars, polysaccharides, and dilute ethanol-soluble extracts. These results would help to improve the production process for fresh-cut Chinese medicines, and increase the understanding of their associated health benefits.

Key words: steaming; *Cistanche deserticola*; phenylethanoid glycoside; antioxidant activity; fresh-cut
compared with three other groups (fresh, directly oven-dried, blanched).

**Experimental Chemicals**

Analytical grade chemicals: methanol, ethanol, α-glucose, sulfuric acid, potassium hydrogen phosphate, and potassium dihydrogen phosphate monohydrate were acquired from Beijing Chemical Works (Beijing, China). Formic acid and phenol were purchased from Sinopharm Chemical Reagent Co. (Shanghai, China). HPLC grade methanol was purchased from Fisher Scientific (Toronto, Canada). The deionized water was obtained using a Milli-Q system (Millipore Corp., Bedford, MA, U.S.A.).

**Samples Extraction**

Samples were collected in spring 2014 in the Ningxia Plantation of Cistanches Herba (106.08°N, 38.24°E, 1124.2 m) in China, and identified by one of us (Prof. Jun Chen). One voucher specimen was deposited at Institute of Medicinal Plant Development, Chinese Academy of Medical Sciences, Peking Union Medical College. About 3 kg of stems of *C. desertica* were randomly collected and rinsed with clean water. The inflorescence parts were removed by a ceramic knife, then the stems were cut into 3 mm slices. Every 100 g slices was measured in weight (W0) as a replicate. Seven experimental treatments with three replicates per treatment were evaluated. For steaming, W0 is the initial weight, and W200 W, and 40°C for 30 min. After extraction, the treated samples were centrifuged for 10 min at 4600×g (TDS; Hunan Herexi Instrument & Equipment Co., Hunan, China). The supernatant was filtered through a 0.45-µm pore size filter for subsequent analyses.

**Determination of Phenylethanoid Glycosides**

Determination of echinacoside, cistanoside A, acteoside, isoacteoside, and 2′-acetylacestoside from *C. desertica* samples was carried out as described by Ma et al. with some modifications. Analysis was performed using a 2695–2996 HPLC instrument (Waters Corp., Milford, MA, U.S.A.) with ultraviolet absorption monitored at 330 nm. The separation was carried out on a Merck Purospher® Star RP-C18 column (250 mm × 4.6 mm, 5 µm) operated at 30°C. The mobile phase at a flow rate of 1 mL/min consisted of solvent A (methanol) and solvent B (0.1% aqueous formic acid, v/v). A gradient elution was operated as follows: 28% A (0–10 min), 28–38% A (10–30 min), 38% A (30–45 min), and the injection volume was 10 µL. A mixed solution containing five reference standards was prepared by dissolving the reference standards in 60% methanol to a final concentration of 0.20 mg/mL for echinacoside, 0.21 mg/mL for acteoside, 0.20 mg/mL for 2′-acetylacestoside, 0.05 mg/mL for cistanoside A, and 0.05 mg/mL for isoacteoside. The solution was then diluted to seven different concentrations to establish calibration curves. The concentration of phenylethanoid glycosides of samples was expressed in g/kg of fresh weight (FW).

**Determination of Oxygen Radical Absorbance Capacity (ORAC)**

The ORAC assay was conducted as described by Huang et al. with some modifications. The synthetic antioxidant BHT was used as a positive control. In brief, 25 µL of dilute sample extracts and 160 µL FL were mixed in a 96-well microplate. The mixture was incubated at 37°C for 15 min, before the addition of 20 µL AAPH. Fluorescence was monitored using 485 nm (excitation) and 520 nm (emission) at 3-min intervals for 72 min by using Fluoroskan Ascent FL (Thermo Scientific, Waltham, MA, U.S.A.). Trolox (2.5–50.0 µmol/L) was used as a reference standard, and the results were expressed as micromoles of Trolox per mass of fresh slice, µmol TE/g FW.

**Determination of 2,2-Diphenyl-1-picrylhydrazyl Free Radical Scavenging Activity (DPPH)**

The DPPH assay was performed as described by Goupy et al. with some modifications. The synthetic antioxidant BHT was used as a positive control. In brief, 1 mL of the dilute sample extract was mixed with 1 mL of 0.2 mmol/L DPPH-methanol solution. The solutions were kept in the dark at 25°C for 90 min, then the absorbance was measured at 517 nm. Trolox (4.0–119.5 µmol/L) was used as a reference standard, and the results were expressed as micromoles of Trolox per mass of fresh slice, µmol TE/g FW.

**Determination of Ferric Reducing Antioxidant Property (FRAP)**

The FRAP assay was performed using the T-AOC assay kit in accordance with the manufacturer’s instructions.

**Soluble Sugars and Polysaccharides**

Sample Preparation of Soluble Sugars

A 0.5-g powdered sample was extracted with 25 mL of 80% ethanol-aqueous solution by KQ-250DE ultrasonic (Kunshan Ultrasonic Instrument Co., Jiangsu, China) at 40 kHz, 200 W, and 40°C for 30 min. After extraction, the treated samples were centrifuged for 10 min at 4600×g (TDS; Hunan Herexi Instrument & Equipment Co., Hunan, China). The supernatant filtered through a 0.45-µm pore size filter for subsequent analyses.
Then, 1 mL of this solution was pipetted into a 10-mL glass tube to evaporate ethanol in a boiling water bath. Distilled water (5 mL) was added to dissolve the residue, then this was transferred into a 100-mL volumetric flask and filled to the mark with distilled water. Finally, 2 mL of this dilute solution was used for determination of soluble sugars.

Sample Preparation of Polysaccharides

The sediments from extracting the soluble sugars were air dried and extracted with 25 mL of distilled water by KQ-250DE ultrasound at 40 kHz, 150 W, and 80°C for 30 min. The first extractive solution was filtered and transferred into a 50-mL volumetric flask. The sediments were re-extracted, and the filtrate was combined with the first extractive solution in the 50-mL volumetric flask and filled to the mark with distilled water. Then, a 5-mL solution of this was pipetted into a 50-mL volumetric flask and filled to the mark with distilled water. Finally, 2 mL of this dilute solution was used for determination of polysaccharides.

Determination of Soluble Sugars and Polysaccharides

The determination of soluble sugars and polysaccharides was carried out using the phenol-sulfuric acid method, as described by Wang et al.24,25 One milliliter of 6% phenol solution was added into 2 mL of the sample solution and mixed well. Then, 5 mL of concentrated sulfuric acid was added rapidly and shook for 5 min. The mixture was transferred to a boiling water bath for 15 min and quickly cooled to room temperature for ultraviolet detection. The ultraviolet absorption was monitored at 490 nm in a UV2550 spectrophotometer (Shimadzu Co., Kyoto, Japan). Distilled water was utilized as a blank. The reference standard anhydrous D-glucose was accurately weighted and dissolved in distilled water to a final concentration of 0.10 mg/mL. Then 1, 2, 3, 4, 5, 6, and 7 mL of the stock solution was pipetted into seven 10-mL volumetric flasks and filled to the mark with distilled water. Then the seven different concentrations of standard solutions were used to establish calibration curves.

Dilute Ethanol-Soluble Extracts

Samples (4.0 g) were accurately weighed to determine their dilute ethanol-soluble extracts, according to the method described in the Chinese Pharmacopoeia (2015 edition).25 The powdered sample was weighed (Wf) and extracted with 100 mL of 50% ethanol-aqueous solution in a 250-mL conical flask with occasional shaking for 6 h, and allowed to stand for 18 h. The extractive solution was filtered and 20 mL of the filtrate was evaporated to dryness, dried at 105°C for 3 h, and cooled in a desiccator (silica gel) for 30 min. Finally, the amount was accurately weighed (Wd). The dilute ethanol-soluble extract content was expressed as g/kg FW of the sample. Dilute ethanol-soluble extracts were calculated as follows: dilute ethanol-soluble extracts (g/kg FW) = [(Wf × 5)/Wd] × (100 − Wf) × 10, where Wf is the initial weight, Wd is the weight measured after extraction, and Wf is the weight loss after oven drying (%).

Statistical Analysis

To clarify any differences among treatment groups, one-way ANOVA was applied using SPSS 13.0 (SPSS Inc., Chicago, IL, U.S.A.). The differences were assessed using the Duncan test with a significance limit of 0.05. The data were expressed as the mean ± standard deviation (S.D.) (n = 3).

Results and Discussion

Weight Loss

Weight of C. deserticola slices directly determines its commercial value in the medicinal herb market. As shown in Table 1, the weight loss of C. deserticola were analyzed after high-heat treatment and oven-drying. Lower levels of weight loss were found when the slices were directly oven dried rather than steamed or blanched. Blanched samples had the highest levels of weight loss. Steamed samples had higher levels of weight loss with longer steaming time. Seven minutes of steaming, the longest time for the fresh-cut slices to hold shape, showed significantly (p < 0.05) higher levels of weight loss after oven-drying than 5 min of steaming. Since phenylethanoid glycosides had been detected in the hot water (data not shown), it suggested that blanching/steaming promoted more water-soluble compounds to be dissolved in the hot water. With respect to weight loss after high-heat exposure, samples steamed for 1 min exhibited extremely low weight loss. Therefore, 1 min of steaming was too short to make the Cistanche tissue brittle, so it was less able to release bioactive compounds (such as phenylethanoid glycosides) during the subsequent extraction procedure, compared with samples that had been steamed longer.

Phenylethanoid Glycosides

Echinacoside, cistanoside A, acteoside, isoacteoside, and 2′-acetyltuloseide levels in slices of C. deserticola processed by different methods are shown in Fig. 1. Samples steamed for 7 min contained 2.16 g/kg FW of echinacoside and 0.29 g/kg FW of cistanoside A, an increase of −140 and −6 fold, respectively, compared with the fresh slices. The content of phenylethanoid glycosides rose sharply when the fresh samples were treated with high heat and drying, especially acteoside, isoacteoside, and 2′-acetyltulose, while they were not detected in the fresh samples. One possible reason for this could be the degradation of phenylethanoid glycosides by peroxidase and β-glucosidase.26,27 These enzymes would be inactivated in the samples dried by high temperatures and decreased water content, leading to high levels of phenylethanoid glycosides being retained in the extracts. Moreover, phenylethanoid glycosides are phenolic compounds, which would be synthesized in fresh plants in response to the stress of high temperature and moisture loss.27

Both steaming and blanching of fresh-cut C. deserticola were reported to enhance the content of echinacoside and acteoside.19,28 However, in the present study, blanching gave a significantly (p < 0.05) lower concentration of acteoside and cistanoside A than drying directly. Regarding the total concentration of the five phenylethanoid glycosides, the blanched samples were still lower than the directly oven-dried ones (1.73, 2.35 g/kg FW, respectively). Slices steamed for 5 and 7 min contained significantly (p < 0.05) higher amounts of acteoside, isoacteoside, and 2′-acetyltulose than directly oven-dried samples. In general, the highest levels of phenylethanoid glycosides were found in the steamed samples, suggesting that the above-mentioned pharmacological activities produced by phenylethanoid glycosides in C. deserticola slices may be enhanced by steaming treatment.

Furthermore, we found that the steaming time was crucial in determining the content of phenylethanoid glycosides. Echinacoside, cistanoside A, acteoside, and isoacteoside showed a similar increasing trend during the steaming process, which increased sharply (at 1, 3 min) and reached their maximum levels at 7 min. No significant changes were observed in the four above-mentioned phenylethanoid glycosides during the steaming process from 3 to 7 min. On the contrary, 2′-acetyl-
The concentration of acteoside increased significantly \((p<0.05)\) with processing time. It is notable that the levels of phenylethanoid glycosides in slices steamed for 1 min were significantly \((p<0.05)\) lower than directly oven-dried slices, with the exception of isoacteoside. Therefore, 1 min steaming of 3-mm fresh-cut \(C.\ deserticola\) was not long enough to inactivate above-mentioned enzymes. Higher total levels of the five phenylethanoid glycosides were observed when the slices were steamed for 5 and 7 min (3.20, 3.52 g/kg FW, respectively) rather than directly oven drying. Steaming from 5 to 7 min more effectively promoted the extraction of phenylethanoid glycosides from \(C.\ deserticola\), leading to a higher level of phenylethanoid glycosides in the extracts.

### Antioxidant Activity

The antioxidant properties of the slices, as assayed by ORAC, DPPH, and FRAP, are presented in Fig. 2. As expected, the ORAC values showed a wide variation among the samples, ranging from 13.34 µmol TE/g FW in fresh samples, to 108.62 µmol TE/g FW at 7 min of steaming. During the steaming process, the ORAC value increased 4-fold between 1 and 7 min steaming. Similar trends were observed in both the DPPH and FRAP assays, showing rapid increases during the steaming treatment. Although the
steam-treated samples initially had lower antioxidant values (at 1 min), they showed a much better retention of antioxidant capacity during the process. In the case of blanching, no significant differences in antioxidant properties were observed compared with directly oven drying. The ORAC antioxidant activity in either raw stems or slices of *C. deserticola* has not been previously reported. However, the ethanol extracts of raw stems of *C. deserticola* has been measured in the DPPH and FRAP assays, showing high antioxidant activity, slightly lower than 2(3)-t-butyl-4-hydroxyanisole (BHA) and higher than BHT. Moreover, phenylethanoid glycosides isolated from *C. deserticola* exhibited strong DPPH scavenging activities, slightly lower than ascorbic acid and higher than α-tocopherol. *C. deserticola* can be a potential source of natural antioxidants, as antioxidant properties of the isolated pure compounds from *C. deserticola* were higher than that of some synthetic antioxidants. As shown in Table 2, BHT exhibited significantly (*p*<0.05) higher antioxidant properties than *C. deserticola* slices steamed for 7 min. Therefore, there is still a big gap between *C. deserticola* slices and synthetic antioxidants of equal quality.

The DPPH assay uses both hydrogen atom transfer (HAT) and single electron transfer (SET) mechanisms, whereas the ORAC and FRAP assays follow the principles of HAT and SET reactions, respectively. In the present study, the general trends of antioxidant capacity evaluated by the three assays were very similar. Thus, we confirmed that dried slices of *C. deserticola* (steamed, directly oven-dried, and blanched) had significantly (*p*<0.05) higher levels of antioxidant activity than fresh ones. Furthermore, steaming for 5 and 7 min significantly (*p*<0.05) enhanced levels of antioxidant activity compared with directly oven drying and blanching. Overall, our results showed that steaming of fresh-cut *C. deserticola* slices was effective in preserving phenylethanoid glycoside levels and antioxidant activity.

**Soluble Sugars, Polysaccharides, and Dilute Ethanol-Soluble Extracts** As shown in Fig. 3, levels of soluble sugars and polysaccharides exhibited the following descending order: **Table 2. Levels of Oxygen Radical Absorbance Capacity (ORAC), 2,2-Diphenyl-1-picrylhydrazyl Free Radical Scavenging Activity (DPPH), and Ferric Reducing Antioxidant Property (FRAP) of *Cistanche deserticola* Slices Steamed for 7 min and BHT (n=3)**

| Analyte                  | ORAC (μmol TE/g) | DPPH (μmol TE/g) | FRAP (μmol TE/g) |
|--------------------------|------------------|------------------|------------------|
| Slices steamed for 7 min | 1212.44±65.04a   | 259.04±15.90a    | 130.77±6.65a     |
| BHT                      | 3845.12±229.66b  | 3044.82±341.86b  | 1251.34±92.96b   |

Values with different superscript letters in the same column are significant at *p*<0.05. Values were expressed as micromoles of Trolox per mass of dry analyte (μmol TE/g).
fresh > directly oven-dried > steamed > blanched. Blanched slices had very low levels of soluble sugars, polysaccharides, and dilute ethanol-soluble extract, corresponding well with their high weight loss. Fresh samples had a significantly \( p < 0.05 \) higher content of soluble sugars (62.89 g/kg FW) and polysaccharides (17.36 g/kg FW) than the other samples, suggesting that heat treatment (oven drying, steaming, blanching) on fresh-cut samples would reduce the extraction of soluble sugars and polysaccharides. In fact, heat treatment inhibited the hydrolysis of phenylethanoid glycosides to release the glucose, rhamnose and so on. Moreover, heat treatment, used as abiotic stress factors on fresh slices, gave rise to the synthesis of several phenylpropanoid compounds including phenylethanoid glycosides. Particularly, sugars contained in the slices were dissolved in the hot water to different extent by steaming or blanching. Thus, it is not surprising to see that the content of soluble sugars decreased by 23.88% in steaming and by 60.82% in blanching, whereas the content of polysaccharides decreased by 41.33% in steaming and by 53.83% in blanching, compared with fresh slices. It has been reported that the steaming process can increase reducing sugars and acidic polysaccharides in Ginseng Radix et Rhizoma, and monosugars, including galactose and glucose, in Rehmanniae Radix. However, the whole dried crude drugs studied in the above-mentioned literature were quite different from the fresh-cut slices used in the present study.

Directly oven-dried slices had the highest content of dilute ethanol-soluble extracts (89.26 g/kg FW), whereas the blanched slices had the lowest (47.60 g/kg FW). Although all the processed slices of *C. deserticola* met the standard of the Chinese Pharmacopoeia (2015 edition) to be qualified as Cistanches Herba, the blanched slices would bring fewer health benefits than directly oven-dried samples for the severe loss of dilute ethanol-soluble extracts. Regarding the steaming process, the trend of soluble sugars was very similar to the trend observed for the dilute ethanol-soluble extracts, decreasing gradually with no significant changes seen from 3 to 7 min. The concentration of polysaccharides fluctuated with a slight increase over the whole steaming period. It is notable that 7 min of steaming showed a well preservation of polysaccharides but a great loss of soluble sugars, whereas 5 min of steaming showed inversely, compared with directly oven-drying.

**Conclusion**

We have reported the effect of steaming on bioactive compounds and antioxidant activity in fresh-cut *C. deserticola* for the first time, and provided important information for developing effective processes for post-harvest treatment of *C. deserticola* stems. Fresh slices showed the worst efficiency for extracting phenylethanoid glycosides and antioxidant compounds, revealing that these substances were prone to enzymatic degradation. In contrast, steamed samples had the highest levels of phenylethanoid glycosides and antioxidant activities. Although blanching slightly enhanced the content of acteoside, isoacteoside, and 2'-acetylacteoside compared...
with directly oven drying, the values for weight, soluble sugars, polysaccharides, and dilute ethanol-soluble extracts all dramatically decreased. For the steaming process, the levels of phenylethanoid glycosides and polysaccharides slightly increased over time. Steaming for 5 and 7 min significantly ($p<0.05$) enhanced total levels of the five phenylethanoid glycosides than directly oven drying. However, the longer the steaming process, the greater the decrease in weight, soluble sugars, and dilute ethanol-soluble extracts. No significant decrease in soluble sugars was observed when slices were steamed from 1 to 5 min compared with directly oven-dried samples. The steaming time had a consistent effect on the antioxidant properties, with a significant increase evaluated by the DPPH, ORAC, and FRAP assays. It was concluded that $C$. _desertica_ slices can be successfully treated with 5 to 7 min of steaming to improve the phenylethanoid glycoside levels and antioxidant activity, while preserving the amounts of soluble sugars, polysaccharides, and dilute ethanol-soluble extracts.

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Conflict of Interest The authors declare no conflict of interest.

Supplementary Materials The online version of this article contains supplementary materials.

References

1) Wang T., Zhang X. Y., Xie W. Y., _Am. J. Chin. Med._, 40, 1123–1141 (2012).
2) Xiong Q., Kadota S., Tani T., Namba T., _Biol. Pharm. Bull._, 19, 1580–1585 (1996).
3) Sui Z. F., Gu F. M., Liu B., Peng S. W., Zhao Z. L., Li L., Shi D. F., Yang R. Y., _Carbohydr. Polym._, 85, 75–79 (2011).
4) Luo L., Wu X. C., Gao H. J., Lv S. Z., Wang J. H., Wang X. W., _Chin. Pharm._, 24, 2122–2125 (2013).
5) Luo L., Tuerxun A., Wang X. W., _Chin. J. New Drugs Clin. Rem._, 29, 115–118 (2010).
6) Xiong Q., Hase K., Tezuuka Y., Tani T., Namba T., Kadota S., _Planta Med._, 64, 120–125 (1998).
7) Wang X. Y., Qi Y., Cai R. L., Li X. H., Yang M. H., Shi Y., _Acta Lab. Anim. Sci. Stn._, 17, 424–427 (2009).
8) Dong Q., Yao J., Fang J. N., Ding K., _Carbohydr. Res._, 342, 1343–1349 (2007).
9) Wang X. Y., Qi Y., Cai R. L., Li X. H., Yang M. H., Shi Y., _Chin. Pharmacol. Bull._, 25, 787–790 (2009).
10) Gao J. Y., Jiang Y., Dai F., Han Z. L., Liu H. Y., Bao Z., Zhang T. M., Tu P. F., _Mod. Chin. Med._, 17, 307–310, 314 (2015).
11) Xue D. J., Zhang M., Wu X. H., Chen X. D., Zhan Y. C., _Chin. J. Chin. Mater. Med._, 20, 687–689, 704 (1995).
12) Lu D., Zhang J. Y., Yang Z. Y., Liu H. M., Li S., Wu B. J., Ma Z. G., _J. Sep. Sci._, 36, 1945–1952 (2013).
13) Xu R., Chen J., Chen S. L., Liu T. N., Zhu W. C., Xu J., _Genet. Resour. Crop Evol._, 56, 157–142 (2009).
14) Ornelas-Paz Jde J., Yahia E. M., _J. Sci. Food Agric._, 94, 1078–1083 (2014).
15) Yun Z., Gao H. J., Liu P., Liu S. Z., Luo T., Jin S., Xu Q., Xu J., Cheng Y. J., Deng X. X., _BMC Plant Biol._, 13, 44 (2013).
16) Gornstein S., Leontowicz H., Leontowicz M., Namiesnik J., Najman K., Dzrewiecki J., Cvikrava M., Martincová O., Katicich E., Trakhtenberg S., _J. Agric. Food Chem._, 56, 4418–4426 (2008).
17) Chang W. T., Cui Y. H., Van Der Heijden R., Lee M. S., Lin M., K., Kong H. W., Kim H. K., Verpoorte R., Hankemeier T., Van Der Gref J., Wang M., _Chem. Pharm. Bull._, 59, 546–552 (2011).
18) Jin Y., Kim Y. J., Jeon J. H., Wang C., Min J. W., Noh H. Y., Yang D. C., _Plant Foods Hum. Nutr._, 70, 141–145 (2015).
19) Lei L., Wang X. Y., CN Patent 200810059282.7 (2009).
20) Tu P. F., Qi X. B., Jiang Y., Feng J., CN Patent 200410048303.7 (2005).
21) Ma Z. G., Yang Z. L., Li P., Li C. H., _J. Liquid Chromatogr. Relat. Technol._, 31, 2838–2850 (2008).
22) Huang D., Ou B. X., Hampsch-Woodill M., Flanagan J. A., Prior R. L., _J. Agric. Food Chem._, 50, 4437–4444 (2002).
23) Goupy P., Hugues M., Boivin P., Amiot M. J., _J. Sci. Food Agric._, 79, 1625–1634 (1999).
24) Wang L. N., Chen J., Yang M. H., Chen S. L., Shi Y., Qi Y., Liu T. N., _Chin. Pharm._, 18, 1620–1623 (2007).
25) “Chinese Pharmacopoeia Commission, Pharmacopoeia of the People’s Republic of China 2015,” Volume IV, China Medical Science Press, Beijing, 2015, p. 202.
26) Tamura Y., Nishibe S., _J. Agric. Food Chem._, 50, 2514–2518 (2002).
27) Hossain M. B., Barry-Ryan C., Martin-Diana A. B., Brunton N. P., _Food Chem._, 123, 85–91 (2010).
28) Chen B. Q., Liu Y. X., Kang W. Y., _Fine Chem._, 27, 342–345 (2010).
29) Yang J. H., Hu J. P., Rena K., Du N. S., _J. Chin. Med. Mater._, 32, 1067–1069 (2009).
30) Prior R. L., Wu X., Schaich K., _J. Agric. Food Chem._, 53, 4290–4302 (2005).