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Relationship between maceration and extraction yield in the production of Chinese herbal medicine

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ABSTRACT

The relationship between maceration and extraction yield in the production of Chinese herbal medicine has been studied. There is a general belief that swelling of herb tissue by maceration enhances the extraction yield of a chemical marker in the afterward extraction; however, this may not be true in general. The extraction of chrysophanol from a seed grounded into powder, *Semen Cassiae*, served as an example to show how maceration enhances the extraction yield of a chemical marker. It is possibly due to the fact that there are so many water soluble substances like starch, sugar and protein in seeds. When water is used as the maceration solvent, it dissolves and removes the water soluble substances, and therefore increases the availability of chemical marker to be extracted by the mixture of ethanol and water. In some other cases, it was found that maceration had no effect on the extraction yield of chemical marker, like the extraction of danshesu from *Radix Salviae Miltiorrhizae* (herb of root) and peaonol from *Cortex Moutan* (herb of root bark). Also, chemical markers may decompose during maceration and extraction, such as extractions of pinoresinol diglucoside from *Cortex Eucommiae* (herb of stem bark) and chlorogenic acid from *Flos Lonicerae* (herb of flower), leading to a decrease of the extraction yield. Based on these experimental results, this study provides general considerations to evaluate if it is cost and time effective to carry out maceration in the production process of Chinese herbal medicine. These considerations include whether the chemical marker is stable during maceration, and whether any substance present in the herb would affect extraction and can be removed during maceration.

1. Introduction

Chinese herbal medicine (CHM) has been used for curing diseases for many years. The production of a CHM decoction generally follows a traditional recipe. The amount of herbs added, and the production process and its corresponding operating conditions are usually strictly followed. Typically, the herbs weighed in a specific proportion are first macerated at room temperature for a certain period of time, followed by extraction at a higher temperature to obtain the CHM decoction. Water is commonly used as the maceration solvent, while water and other solvents such as ethanol or acetone are commonly used in the high temperature extraction process. Two different forms of herbs, namely raw herbs and powders, can be used in the CHM production process. Raw herbs are produced from crude herbs by cutting them into small pieces and can be further ground to produce powders. The selection of which form to be used in the herbal formula is purely

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Table 1 – HPLC method for determining chemical markers concentration from different herbs.

Part of herbs	Herb	Chemical marker	UV detection wavelength (nm)	Mobile phase	Flow rate (mL/min)	Injection volume (μL)
Seed	*Semen Cassiae*	Chrysophanol	254	0.1% Acetic acid and methanol at 15:85 (v/v)	0.8	5
Root	*Radix Salviae Miltiorrhizae*	Danshensu	270	Gradient elution system: 0.1% acetic acid (A) and acetonitrile with 0.1% acetic acid (B); gradient program: 0–30 min, 10–17% B; 30–40 min, 17–30% B; 40–100 min, 30–90% B; 100–105 min, 90–5% B	1	40
Root bark	*Cortex Moutan*	Paeonol	254	Gradient elution system: water (A) and acetonitrile (B); gradient program: 0–10 min, 10–30% B; 10–20 min, 30–80% B; 20–23 min, 80% B	0.8	20
Flower	*Flos Lonicerae*	Chlorogenic acid	327	1% Acetic acid-water solution and methanol at 25:75 (v/v)	1	10
Stem	*Caulis Lonicerae*	Chlorogenic acid	327	1% Acetic acid-water solution and methanol at 25:75 (v/v)	1	20
Stem bark	*Cortex Eucommiae*	Pinoresinol diglucoside	210	Gradient elution system: water (A) and acetonitrile (B); gradient program: 0–30 min, 10–20% B; 30–40 min, 20–40% B	0.8	20

the decision of a herbalist and no general guideline is developed for such selection. No matter raw herbs or powders are used in the CHM production process, maceration is still commonly employed before the extraction process (Atawodi, 2003; Cheung et al., 2012; Hempen and Fischer, 2009; Xu et al., 2012a; Yu et al., 2013; Zhao, 1997).

Many studies reported that maceration, in general, is beneficial to the CHM production process. A study of producing Yinchenhao decoction from raw herb concluded that cold water maceration was beneficial as the amount of active ingredients being extracted in a high-temperature extraction process was increased from 19.5% to 21.3% if the raw herbs were macerated before extraction (Tian et al., 2008). A similar observation was also reported when herb powders were used in the CHM production process. When maceration was not carried out in the manufacturing process, the amount of chrysophanol extracted from *Semen Cassiae* by 50% water and 50% ethanol was 197.71 mg per 100 g of *Semen Cassiae*. The extracted amount increased to 338.15 mg per 100 g of *Semen Cassiae* when the herb was first macerated in water at room temperature, followed by adding the same amount of acetone as extraction solvent to effect extraction at a higher temperature (Chan et al., 2009).

Although there are general recommendations and practices by the CHM manufacturers to macerate the herbs before extraction, it was also reported that the amount of active ingredients extracted from non-macerated herbs and herbs macerated for 30 min was not significantly different (Wong et al., 1990). Only if the herbs were macerated for a longer period of time (12 h), the amount of active ingredients being extracted was increased. Therefore, the general belief of maceration increases the extraction yield may not be true in general. Various aspects have to be considered in determining whether maceration is beneficial to the overall process. This paper aims at providing some guidelines for the CHM manufacturers to consider whether maceration is indeed necessary. Various herbs, from different parts of plants, are macerated for different periods of time, and compared with non-macerated herbs on the yield of active ingredients being extracted during the high temperature extraction process. These data provide the basis of providing general guidelines for maceration.

2. Materials and methods

2.1. Herbs and chemicals

Raw herb, including *Semen Cassiae*, *Radix Salviae Miltiorrhizae*, *Cortex moutan*, *Flos Lonicerae*, *Caulis Lonicerae*, and *Cortex Eucommiae*, were purchased from Hong Kong market (Po Lung Hong, Ko Shing Street, HK) and kept in a desiccator controlled at 20% RH before experiments. All herbs were authenticated by their organoleptic characteristics according to the Chinese Pharmacopoeia. Double deionized (DDI) water with a resistivity of 18.2 MΩ cm at room temperature and ethanol (HPLC grade, Merck Darmstadt, Germany) were used as solvent during maceration and extraction. HPLC grade acetonitrile and methanol were purchased from TEDIA company, Inc. USA and Mallinckrodt Baker, Inc. USA, respectively, while analytical grade acetic acid was supplied by Fluka. The chemical marker corresponds to each herb for HPLC analysis is summarized in Table 1 and their chemical structures are shown in Fig. 1. Except for the standard solution of chrysophanol (purity 99.0%) which was purchased from National Institute for the Control of Pharmaceutical and Biological Products (Beijing, China), the standard solutions of other chemical markers were purchased from Applied Scientific Instrument (HK) Co. Ltd., with purities higher than 98%.

2.2. Extraction process and analytical methods

Raw herb was ground into powders by a blender (Rong Tsong Precision Technology Co., Taiwan). Except *Cortex Eucommiae* which has sticky filaments after grinding, all herb powders were sieved such that the particle size used in this study equal to 1.0 mm or less. All the herb powders were stored in a 4 °C refrigerator before use. Conventional heat and reflux extraction was used as the extraction method in this study and the schematic diagram of the experimental setup is depicted in Fig. 2. For each extraction experiment, 5 g of raw herb or herb powders was weighted and added to a 250 mL round-bottom flask. The herbs were then macerated in 50 mL solvent (except specified otherwise), either water or a specific weight percentage of ethanol solution, for a specific period of time at room