DOI: 10.15806/j.issn.2311-8571.2014.0020

Geographical Indications for Medicinal Plants: Globalization, Climate Change, Quality and Market Implications for Geo-Authentic Botanicals

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ABSTRACT

Pharmacopoeial standards for crude drugs are established based on analysis of authenticated specimens which should be representative of the quality of material traditionally specified in systems of traditional medicine from species' geographical origin. This reflects the 'geo-authentic' material that corresponds to traditional ecological and medical knowledge. In cases where specimens are obtained from cultivation outside of the species origin, this 'authenticated' material will not be 'geo-authentic'.

There is a growing trend for the protection of 'geographical indication' (GI) botanicals in the context of intellectual property rights. GI botanicals are named after a geographical area, indicating production within a particular area, quality and characteristics dependent on natural, historical and cultural factors. However, with the globalization of systems of traditional medicine such as Ayurvedic medicine and traditional Chinese medicine, Asian species are being introduced to cultivation outside of their geographical origins particularly in the EU and US.

In contrast to the Chinese concept of 'daodi' and European concepts of 'provenance' or 'terroir' is the competing trend for 'locally grown' herbs, i.e. cultivated closer to where they will be used. Reasons include concerns about quality control, contamination from polluted air, soil and water in some source countries, climate change, supply chain security and traceability, costs of production and price pressure.

This review looks at selected agronomic experiments aiming to discern differences between geo-authentic medicinal herbs vs. introduced crops and whether the global market cares to make a distinction or pay a price premium for articles with designations of geographical origin of specified quality.

Key words: Appellation of Origin, Daodi, Geo-authentic, Geographical Indication, Designation of Origin

Abbreviations: AO, Appellation of Origin, GI, geographical indication; PDO, protected designation of origin; PGI, protected geographical indication; MAP, medicinal and aromatic plant; TCM, traditional Chinese medicine; TEK, traditional ecological knowledge; TSG, traditional speciality guaranteed.

INTRODUCTION

Pharmacopoeial standards for verifying the composition, identity, purity, quality, and strength of a botanical substance are developed based on the analysis of authenticated specimens. In principle, the specimens should be representative of the quality and grade that has been traditionally specified for the intended uses.

When new and modernized pharmacopoeial monographs for medicinal plants that emanate from specific systems of traditional medicine (e.g. traditional Chinese medicine, Ayurvedic medicine, Siddha medicine, Unani medicine) are developed outside of the species' geographical and cultural context, the standards may, or may not, represent geo-authentic material and/or correspond to certain qualities defined in traditional medicine formularies and pharmacopoeias, i.e. those qualities associated with observed clinical efficacy.

In cases where specimens that are to be used for monograph development are obtained from cultivation outside of the species native range, this "authenticated" material will not be "geo-authentic." Geo-authentic ('daodi') botanicals refer to those with specific germplasm, wild collected or cultivated in their traditional geographical origin, of a specified biological age at maturity, with specific production techniques and processing methods[1].

Consequences of introducing botanical species to cultivation in ecosystems that are significantly different from their native origin may include measurable differences in chemical composition and strength or even observable differences in morphology. Furthermore, agricultural and collection practices and post-harvest processes that differ significantly from the traditional practices in geographical origin may result in measurable or observable differences if compared against geo-authentic specimens, especially in cases of botanicals that are traditionally subjected to unique processes or treatments specified in the formularies and pharmacopoeias used in systems of traditional medicine[2].

There is a growing trend at both the national and international level for the defining, specifying and protecting of "geographical indication" (GI) botanicals. A GI botanical is named after a geographical area, indicating that it is produced within a particular area, and its quality and

characteristics depend on natural, historical and cultural factors.

At the same time there is a competing trend for 'locally grown' herbs, i.e. medicinal plants cultivated away from their native origins and closer to where they will be processed and used, in clinical practice and in herbal medicinal products. Reasons for this include concerns about quality control, contamination from polluted air, soil and water in some source countries, climate change, supply chain security and traceability, as well as costs of production and price pressure.

Traditional Chinese Medicine (TCM) plants are now being cultivated on farms throughout North America, parts of Europe and Africa. Conversely a number of species of South American biodiversity are now being cultivated in Asian countries.

This review looks at selected recent agronomic experiments aiming to discern differences between geo-authentic wild or cultivated medicinal crops vs. introduced crops and whether today's market even cares to make a distinction and/or pay a price premium for botanical articles with designations of geographical origin of specified quality.

There are opposing theories on the implications for TCM practice concerning quality and efficacy of preparations when using Chinese medicinal herbs grown outside of their geographical origin and traditional production areas. Conversely, the same questions are raised for medicinal plants native to the Americas increasingly being brought into large-scale cultivation in Asia.

Proponents of geo-herbalism believe that 'daodi' crude drugs are superior in pharmaceutical quality and clinical effect by comparison to crude drugs of the same species that are cultivated outside of their geographical origin. Conversely, proponents of the locally-grown movement believe that herbs grown by local smallholder organic farms, regardless of the species' geographical origin, will be of superior quality to the typical grades of Chinese herbs commercially available in the United States. The latter group may, or may not, be concerned with traditional methods of assessing and verifying therapeutic quality of a crude drug such as those specified in pharmacopoeial monographs.

GEOGRAPHICAL INDICATIONS FOR MEDICINAL AND AROMATIC PLANTS

Regulatory frameworks for geographical indication (GI) protection and registration have been implemented in several countries including some of the world's leading producers and exporters of medicinal and aromatic plants (MAP) and extracts such as the European Union (EU), People's Republic of China (PRC), and Republic of India, among others[3]. Additionally, some GI botanicals that are protected on a national level are also registered through the World Intellectual Property Organization (WIPO) for additional protection under the 'Lisbon Agreement for the Protection of Appellations of Origin and Their International Registration'.

Xu et al (2013) assert, within the context of globalization and modernization of TCM, that botanical raw materials must be produced through sustainable agriculture and/or sustainable wild collection methods and according to good agricultural and collection practices (GACPs) for medicinal plants. Furthermore, the scientific principles of 'daodi' (geo-authenticity) should be taken into consideration because in TCM theory geo-authentic medicinal plants are still regarded as superior in quality and effects by comparison to same species introduced to cultivation in other regions. Finally, the crude drugs must be grown and processed in a manner that results in reproducible quality meaning that test results will consistently conform to the standards of the Chinese Pharmacopoeia[4].

The European Union (EU) has implemented three schemes for GI protection:

***Protected Designation of Origin (PDO)*:** may apply to botanicals that are produced, processed and prepared in a given geographical area using recognized 'know-how'. Medicinal plants that have been granted PDO status in the EU include cultivated and/or wild-collected liquorice (*Glycyrrhiza glabra* L., Fabaceae) root from the Calabria region of the Italian Republic.

***Protected Geographical Indication (PGI)*:** may apply to botanicals that are closely linked to a geographical area and at least one of the stages of production, processing or preparation takes place in the area. Hop (*Humulus lupulus* L., Cannabaceae) female inflorescence grown in the Tettnang Region of the Federal Republic of Germany has PGI protection. Some Tettnang hops production is used in the manufacture of herbal medicinal products but most is reserved for beer making.

***Traditional Speciality Guaranteed (TSG)*:** products are those that highlight traditional character, either in the composition or means of production.

Table 1 provides examples of medicinal and aromatic plants produced in Europe that have PDO or PGI status in the European Community. The national GI specifications for some of these medicinal plants make claims of superior quality by comparison to European Pharmacopoeia standards as well as superior clinical efficacy for the traditional medical uses.

The People's Republic of China has also implemented three parallel regulations that provide special provisions for GI protection:

***General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)*:** manages a GI system under special regulations defining GI products as agricultural products coming from a defined area with raw materials originating entirely or partially within the defined zone, and being processed in this area in compliance with the GI specifications. For example, Fushun Liaoning schisandra (*Schisandra chinensis* (Turcz.) Baill; Schisandraceae) fruit is protected under this regulation.

***State Administration for Industry and Commerce (SAIC)*:** administers a trademark law defining GI products as those from a specific region, with quality, reputation and other features that are determined by natural or cultural elements of the region. For example, Luoping yellow ginger (*Zingiber*

Table 1. Selected Maps with Geographical Indication (GI) Protection in the EU

Medicinal And Aromatic Plant Or Preparation	Geographical Indication	EU Country	Type
Camelina seed oil (*Camelina sativa* (L.) Crantz or *Camelina silvestris* Wallr.; Brassicaceae)	Olej rydzowy (Gold-of-pleasure oil or Camelina oil)	Republic of Poland	TSG
Capsicum fruit (*Capsicum annuum* L. var. Longum DC, Solanaceae)	Kalocsai fűszerpaprika örlemény	Hungary	PDO
Caraway fruit (*Carum carvi* L., Apiaceae)	Český kmín (Czech Caraway)	Czech Republic	PDO
Chamomile flower (*Matricaria recutita* (L.) Rauschert, Asteraceae)	Chamomilla Bohemica (Bohemian Chamomile)	Czech Republic	PDO
Wild Chamomile flower (*Matricaria chamomilla* L., Asteraceae)	Alföldi kamillavirágzat (Wild Alföld Chamomile)	Hungary	PDO
French Lavender flower oil (*Lavandula angustifolia* Mill., Lamiaceae)	Huile essentielle de lavande de Haute-Provence (Essential oil of Haute-Provence Lavender)	French Republic	PDO
Hop female inflorescence (*Humulus lupulus* L., Cannabaceae)	Tettnanger Hopfen (Tettnang Hops)	F.R. of Germany	PGI
	Žatecký chmel (Saaz Hops)	Czech Republic	PDO
Horseradish root (*Armoracia rusticana* P. Gaertn. et al., Brassicaceae)	Hajdúsági torma (Hajdúság Horseradish)	Hungary	PDO
	Steirischer Kren (Styrian Horseradish)	Republic of Austria	PGI
Liquorice root and rhizome (*Glycyrrhiza glabra* L. var. *typica* 'Cordara', Fabaceae)	Liquirizia di Calabria (Calabrian Liquorice)	Italian Republic	PDO
Mastic gum resin (*Pistacia lentiscus* L. var. *chia* (Desf. ex Poiret) DC., Anacardiaceae)	Μαστιχέλαιο Χίου (Chios Mastic)	Hellenic Republic	PDO
Saffron style & stigma (*Crocus sativus* L., Iridaceae)	Azafrán de la Mancha (Mancha Saffron)	Kingdom of Spain	PDO
	Κρόκος Κοζάνης (Krokos Saffron)	Hellenic Republic	PDO
	Zafferano dell'Aquila (Aquila Saffron)	Italian Republic	PDO
Yellow nut sedge tuber (*Cyperus esculentus* L., Cyperaceae)	Chufa de Valencia	Kingdom of Spain	PDO

Legend:
EC European Community
PDO Protected Designation of Origin
PGI Protected Geographical Indication
TSG Traditional Speciality Guaranteed

officinale Roscoe; Zingiberaceae) rhizome, cultivated in Luoping County, eastern Yunnan Province, carries a GI trademark granted by SAIC.

***Ministry of Agriculture (MOA)*:** administers a third GI system that focuses mainly on raw agricultural produce whereby an agricultural GI product is named after a geographical area, indicating that it is produced within a particular area, and its quality and characteristics depend on natural, historical and cultural factors.

Table 2 provides examples of medicinal plants that are used in TCM that have protected GI status from some origins.

SELECTED AGRONOMIC EXPERIMENTS OUTSIDE OF GEOGRAPHICAL ORIGINS

Chinese angelica

Chinese angelica (*Angelica sinensis* (Oliv.) Diels; Apiaceae) is a plant of Chinese biodiversity, occurring in the wild and also cultivated in forests and shrubby thickets at altitudes of between 2,500–3,000 m in Chinese provinces of Gansu, Hubei, Shaanxi, Sichuan, and Yunnan[5].

Outside of its geographical origin, agronomic experiments by Korean National Institute of Crop Science researchers, attempting to cultivate Chinese angelica in Republic of Korea, found that it would not grow at low altitudinal plane areas. While it could be grown at higher elevations in Korea, root yield was too low to be considered an economically viable crop[6].

Field experiments carried out by Bavarian State Research Centre for Agriculture concluded that Chinese angelica could not be cultivated under southern German conditions although other TCM plants were determined to be feasible for commercial-scale cultivation[7].

In China, agronomic experiments have been carried out to determine best altitude for Chinese angelica cultivation within its area of geographical origin (Minxian County,

Table 2. Selected Medicinal Plants used in TCM with Geographical Indication (GI) Designations

Medicinal Plant	Appellation / Designation of origin	Country	Type
绿茶 Cha Tea leaf (*Camellia sinensis* (L.) Kuntze, Theaceae)	龙井茶 (Longjing Tea)	P.R. of China	EC-PDO
刺五加 Ciwujia Eleuthero root (*Eleutherococcus senticosus* (Rupr. & Maxim.) Maxim., Araliaceae)	백두산 (Paektusan Acanthopanax senticosus)	D.P.R. of Korea	WIPO-AO
甘草 Gancao Liquorice root and rhizome (*Glycyrrhiza glabra* L., Fabaceae)	Liquirizia di Calabria (Calabrian Liquorice)	Italian Republic	EC-PDO
干姜 Ganjiang Ginger rhizome (*Zingiber officinale* Roscoe, Zingiberaceae)	罗平小黄姜 (Luoping Small Yellow Ginger)	P.R. of China	GI Trademark
胡椒 Hujiao Pepper fruit (*Piper nigrum* L., Piperaceae)	Malabar Pepper	Republic of India	IPI-GI
啤酒花 Pijiuhua Hop female inflorescence (*Humulus lupulus* L., Cannabaceae)	Tettnanger Hopfen (Tettnang Hops)	F.R. of Germany	EC-PGI
人参 Renshen Asian ginseng root (*Panax ginseng* C.A. Meyer, Araliaceae)	抚顺林下参 (Fushun Forest Ginseng)	P.R. of China	AQSIQ-GI
五味子 Wuweizi Schisandra fruit (*Schisandra chinensis* (Turcz.) Baill., Schisandraceae)	抚顺辽五味子 (Fushun Liaoning Schisandra)	P.R. of China	AQSIQ–GI
西紅花 Xihonghua Saffron style and stigma (*Crocus sativus* L., Iridaceae)	Κρόκος Κοζάνης (Krokos Saffron)	Hellenic Republic	EC-PDO

Legend:
AO Appellation of Origin
AQSIQ General Administration of Quality Supervision, Inspection and Quarantine
EC European Community
GI Geographical Indication
PDO Protected Designation of Origin
PGI Protected Geographical Indication
IPI Intellectual Property India
WIPO World Intellectual Property Organization

Gansu Province). Researchers found that the polysaccharide content of the roots increased gradually corresponding with the increase of elevation of the cultivated area within 2,300 m to 2,900 m. At altitudes above 2,900 m, the polysaccharide content decreased gradually corresponding with the increase of cultivated area elevation up to 3,100 m. Polysaccharide content was the highest in roots harvested at between 2,600 m to 2,900 m in altitude[8].

Astragalus

Astragalus (*Astragalus membranaceus* (Fisch.) Bge. var. *mongholicus* (Bge.) Hsiao, Fabaceae) grows in the steppes, in meadows, coniferous forests, and montane zone at altitudes between 800–2000 m. In the provinces of Gansu, Hebei, Heilongjiang, Jilin, Nei Mongol, Shaanxi, Shandong, Shanxi, Sichuan, Xinjiang, and Xizang, and outside of China in Kazakhstan, Mongolia, and Russian Far East (Siberia)[9].

Agronomic experiments by Shannon et al (2014) to adapt astragalus varieties for commercial cultivation in the south-eastern United States have been carried out through Auburn University in the state of Alabama. These experiments showed that selected varieties had good adaptability in terms of root weight (yield) and root quality (relatively high concentration of astragaloside IV) and may have potential for commercial cultivation in the southeastern US. Certain problems that were encountered during the experimental cultivation such as root rot disease and white fringe beetles (*Naupactus* spp., Curculionidae) feeding on roots and crowns would need to be

solved before astragalus can be considered to be a suitable economic crop for the region[10].

Maca

Maca (*Lepidium meyenii* Walpers; Brassicaceae) hypocotyl is an important medicinal plant crop of Peru for production of value-added health ingredients and natural products for domestic consumption and export market. Native to the high Andes of Peru, grown in the puna agroecologic zone above 4000 m, domestication of maca is estimated to have begun at least 2,000 years ago in the Junín Plateau[11].

The Peruvian National Institute for the Defense of Competition and Protection of Intellectual Property (INDECOPI) issued a 'Designation of Origin' specification for 'Maca Junín-Pasco', i.e. maca that is cultivated and produced in specified geographic zones and altitudes within the Provinces of Junín and Pasco, which was followed by registration of an 'Appellation of Origin' through the World Intellectual Property Organization (WIPO)[12].

Agronomists in the Czech Republic have carried out maca cultivation experiments, both field and greenhouse. Earlier reports informed that maca grown at lower altitudes, for example in Germany, did not even form hypocotyls. While the Czech researchers were indeed able to cultivate maca, the field grown material contained a level of macamides approximately 6 times lower than geo-authentic Peruvian maca and no macamides were detected at all in hypocotyls of greenhouse grown maca. The researchers concluded that it was not feasible to produce maca in Czech Republic of a composition and quality comparable to Peruvian Maca[13].

Experimental cultivation and processing of maca however has been ongoing for several years in Yunnan Province of China[14].

IMPLICATIONS OF 'LOCALLY-GROWN' TREND ON TCM

According to Heuberger et al (2010), physician members of DECA (Association for the Documentation of Chinese Herbal Therapy) and SMS (International Society for Chinese Medicine) have used Chinese herbs from experimental production in Bavaria, Germany in their clinical practice and have reported high pharmaceutical quality. Chinese medicinal plants under commercial cultivation in Bavaria include:

- Fragrant angelica: *Angelica dahurica* (Fisch.) Benth. & Hook. f. ex Franch. & Sav., Apiaceae
- Xanthium: *Xanthium sibiricum* Patrin ex Widd., Asteraceae
- Chinese salvia: *Salvia miltiorrhiza* Bunge, Lamiaceae
- Siler: *Saposhnikovia divaricata* (Turcz.) Schischk., Apiaceae
- Astragalus: *Astragalus membranaceus* (Fisch.) Bge. var. *mongholicus* (Bge.) Hsiao, Fabaceae
- Chinese skullcap: *Scutellaria baicalensis* Georgi, Lamiaceae
- Siegesbeckia: *Siegesbeckia pubescens* (Makino) Makino, Asteraceae
- Chinese motherwort: *Leonurus japonicus* Houtt., Lamiaceae
- Yin-chen wormwood: *Artemisia scoparia* Waldst. et Kit., Asteraceae[7].

In the United States, Gardner et al (2015) have reported promising results from preliminary agronomic trials indicating that selected Chinese medicinal plant species can grow well under controlled cultivation in the state of Massachusetts. The studied species were:

- Chinese giant hyssop: *Agastache rugosa* (Fischer & C. Meyer) Kuntze, Lamiaceae
- Schizonepeta: *Schizonepeta tenuifolia* (Benth.) Briq., Lamiaceae
- Siberian motherwort: *Leonurus sibiricus* L., Lamiaceae
- Chinese motherwort: *Leonurus japonicus* Houtt., Lamiaceae[15].

In this first phase of determining feasibility of cultivation of these four species in the United States, the harvested materials were not yet subjected to laboratory evaluation in order to determine if their composition, quality and strength would conform to the standards established in the Chinese Pharmacopoeia. Nor have comparative trials for determination of clinical efficacy been carried out. Nonetheless, there is reportedly strong interest from American farmers looking for higher-value new crops and also from an increasing number of American practitioners of TCM who may prefer to dispense locally grown Chinese herbs to their patients.

In parts of rural eastern and southern United States where tobacco (*Nicotiana tabacum* L.; Solanaceae) leaf was once the main economic crop, Chinese medicinal plants are increasingly being introduced as new cash crops for small farmers. Medicinal plant farmers in western North Carolina claim that they share the same latitudes and elevations of the mountainous provinces in China that are ideal for cultivation of certain Chinese medicinal plants. Some farmer organizations are already selling American-grown Chinese herbs to distributors that supply practitioners of TCM nationally[16].

Chinese medicinal plants being cultivated in North Carolina and sold to clinicians, for example from cooperative farmer members of the Appalachian Botanical Alliance, include the aforementioned herbs Chinese giant hyssop, schizonepeta and Chinese motherwort as well as:

- Chrysanthemum: *Chrysanthemum morifolium* Ramat., Asteraceae; and
- Sweet wormwood: *Artemisia annua* L., Asteraceae.

In the neighboring state of Virginia, farmers belonging to the Appalachian Medicinal Herb Growers Consortium, part of the 'Farm Prosperity Project and Medicinal Herbs for Commerce' are growing Chinese herbs for the local TCM practitioner market including:

- Anemarrhena rhizome: *Anemarrhena asphodeloides* Bunge, Liliaceae
- Astragalus root: *Astragalus membranaceus* (Fisch.) Bge. var. *mongholicus* (Bge.) Hsiao, Fabaceae

- Trichosanthes root: *Trichosanthes Kirilowii Maxim*, Cucurbitaceae.

The Appalachian Medicinal Herb Growers Consortium presently has 9 member farms with another 20 farms reportedly planning to join. With an estimated 27,000 practitioners of TCM in the U.S., Jean Giblette, a long time grower of Chinese medicinal plants at High Falls Gardens in the state of New York, estimates the U.S. market for Chinese herbs at between $200 million to $300 million a year.

Some Chinese medicinal plants already widely cultivated by American farmers in several states include astragalus and ginkgo (*Ginkgo biloba* L., Ginkgoaceae) leaf, among others. Table 3 provides a list of selected American producers of ginkgo leaf along with farm coordinates (altitude, latitude and longitude).

Supporting the apparent popularity of domestic cultivation of Chinese medicinal plants in the United States are organizations such as Chinese Medicinal Herb Farm (Petaluma, California) that provide full-season training courses from nursery to field production including soil management, planting, cultivation, harvesting and drying of TCM crops, as well as Asian medicinal herb production on-line tutorials, and handbooks for cultivators of TCM herbs[17].

IMPLICATION OF CLIMATE CHANGE ON DAODI

Traditional collection practices may include specific geographic locations and times of harvest for each medicinal plant, traditional and local resource management systems, and quality assessment based on traditional knowledge, for example geoherbalism as a concept of quality applied in TCM.

Daodi herbs account for the highest volume and economic value in TCM. Of the 500 most commonly used Chinese crude drugs about 200 are recognized as daodi and these account for about 80% of total usage in TCM[18].

China's Food and Drug Administration (CFDA) in their 2002 'Good Agricultural Practice (GAP) for Chinese Crude Drugs (interim)' defines daodi crude drugs as 'traditional Chinese crude drugs with specific germplasm, production sites, or with specific production techniques and processing methods… daodi crude drugs should be processed according to traditional methods. Any change in methods should be based on sufficient experimental data, and should not affect the quality of the Chinese crude drugs'[19]. More recently, Zhou et al (2012) elaborated on the definition of "daodi medicinal material" as "medicinal material that is produced and assembled in specific geographic regions with designated natural conditions and ecological environment, with particular attention to cultivation technique, harvesting and processing. These factors lead to quality and clinical effects surpass those of same botanical origin produced from other regions, and thus is widely recognized and has long enjoyed a good reputation"[20].

Threats to the continuation of this traditional system of quality assessment were articulated by Leung and Cheng (2008) whereby they assert that the traditional daodi concept may need to be abandoned due to emerging factors including climate change, pollution (air, soil and water), unsustainable overharvesting, and soil loss and degradation (development, erosion, sedimentation)[21]. Meanwhile, the international demand for TCM continues to increase and agencies of the

Table 3. Selected Farms Cultivating Yinxingye in North America

Yinxingye: dried leaf of *Ginkgo biloba* L.; Ginkgoaceae	
Geographic Origin: Possibly native in NW Zhejiang (Tianmu Shan); widely cultivated below 2000 m in Anhui, Fujian, Gansu, Guizhou, Henan, Hebei, Hubei, Jiangsu, Jiangxi, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan.	
Farm name	**Coordinates**
Eclectic Farm	Sandy, Oregon USA alt: 305 m, lat: 45°23′51″N, long: 122°15′59″W
Gaia Farm	Brevard, North Carolina USA alt: 680 m, lat: 35°14′30″N, long: 82°43′43″W
Garnay Industries	Dalzell, South Carolina USA alt: 66 m, lat: 34°1′11″, long: N 80°25′47″W
OWH Farm	Sandy Oregon USA alt: 305 m, lat: 45°23′51″N, long: 122°15′59″W
Pacific Botanicals	Grants Pass, Oregon USA alt: 293 m, lat: 42°26′20″N, long: 123°19′42″W
Quailhurst LLC	Sherwood, Oregon USA alt: 59 m, lat: 45°21′25″N, long: 122°50′36″W
Sego's Herb Farm LLC	La Center, Washington USA alt: 32 m, lat: 45°51′50″N, long: 122°40′7″W
Trout Lake Farm	Trout Lake, Washington USA alt: 577 m, lat: 45°59′44″N, long: 121°31′14″W
Western Oregon Organic Farms	Aurora, Oregon USA alt: 42 m, lat: 45°13′49″N, long: 122°45′19″W
Zak Woods Herb Farm	Hyde Park, Vermont USA alt: 203 m, lat: 44°35′42″N, long: 72°36′54″W

Chinese government continue to establish industry-supporting policies for the export promotion of TCM. Indeed, China's 12th Five Year Plan (2011–2015) expressly aimed to vigorously develop export promotion of Chinese culture and TCM to increase its share of the total foreign trade[22].

The primary daodi origin, one of the most widely used herbs in TCM, liquorice (*Glycyrrhiza uralensis* Fisch., Fabaceae) root and rhizome, is Inner Mongolia Autonomous Region. The wild populations of liquorice have diminished rapidly in its primary daodi origin areas since the 1970s and it is now classified as an endangered and nationally-protected medicinal plant species in China. While some of the demand is now being supplied with liquorice that is being cultivated in Inner Mongolia (in same region of daodi wild collection), much of the supply has shifted to wild collection sources in the Xinjiang Uyghur Autonomous Region[21,23]. This raises the question of whether liquorice that has been introduced to cultivation in its traditional daodi origin can actually be classified as daodi, and therefore of comparable quality to wild-collected liquorice of the region. Another question concerns populations of liquorice diminishing in one part of northern China but adapting or presently stable in other parts of China, areas that historically were not considered to be within the daodi origin of the species. In consideration of climate change, adaptation or possible shifting of geographical distribution of a plant species, the concept of daodi must be reexamined.

DISCUSSION

On the one hand, the Chinese concept of 'daodi', and similar European concepts of 'provenance' or 'terroir' are generally equated with high quality, i.e. the genuine article worth importing and paying a price premium. Indeed national authorities of many countries are going through the regulatory processes to secure geographical indication protection for certain of their unique regional products including some medicinal and aromatic plants and/or traditional preparations made from them.

On the other hand, there is a growing mistrust of the quality and safety of goods imported from far away, regardless of origin, especially agricultural products that may have grown in contaminated or polluted conditions and/or not according to good agricultural and hygienic practices necessary to prevent contamination by pathogenic bacteria. Adding to this is a strengthening 'locally grown' movement in North America as well as in Europe. There is a belief among many American and European farmers that they can learn how to grow Asian medicinal plant species that will be comparable or better in quality than geo-authentic material, even when the selected site for cultivation is significantly different from the ecosystem of the species' geographical origin.

Conversely, some emblematic medicinal and aromatic plant crops of Latin America are now being cultivated in Asia, for example maca (*Lepidium meyenii* Walpers; Brassicaceae) hypocotyl, a native crop of the High Andes of Peru, sacha inchi (*Plukenetia volubilis* L., Euphorbiaceae) seed, native to the high altitude rainforests of the Andean region[24], and stevia (*Stevia rebaudiana* (Bertoni) Bertoni, Asteraceae) leaf[25], an herb native to the highlands of northern Paraguay.

Does the market care about geographical indications? In certain food and beverage product categories it is clear that the market supports price premiums for perceived higher quality of geographical indication products, especially beers, cheeses, chocolates, coffees, olive oils and wines. It is not yet clear whether the market views Chinese 'daodi' or geographical indication medicinal and aromatic plants through the same lens.

Using Paraguayan stevia leaf as a case in point, in the context of intellectual property law, a Paraguayan presidential decree was issued in 2004 which recognized the species *Stevia rebaudiana* as a native species originating from Paraguay, taking into account its discovery, botanical taxonomic classification, identification of its active principles, and agricultural practices. Stevia had already been introduced to China in the 1970's and commercial cultivation picked up there during the 1980's. China quickly became the number one global producer and exporter of stevia leaf and extracts thereof and remains so today. In a USAID report for Paraguay, an industry survey found that American buyers and importers associated stevia with China, and not with Paraguay. There does not appear to be a preference in the American market for geo-authentic stevia. If the quality of Asian grown stevia is comparable or better and the price is comparable or lower, the market will likely follow the lower price[26].

Stevia is only one example. Controlled comparative studies to assess and quantify the differences in composition, strength, biological activity and clinical effect are needed in order to determine whether geo-authentic medicinal plants are generally superior in quality and effect over same species plants grown outside of their geographical origin, as is the belief in TCM theory. Such data will be important for practitioners of TCM in America and Europe who may prefer to use locally-grown herbs over geo-authentic herbs in their formulations for patients. There are preliminary data showing that certain introduced TCM crops appear to be of comparable quality to geo-authentic materials as well as certain crops determined to be unsuitable outside of geographical origin. Conclusive comparative data, that would result from not only laboratory analysis for quality and biological-activity testing but also clinical data for determination of efficacy in humans, is lacking at this point.

ACKNOWLEDGEMENTS

The author gratefully acknowledges Zoë E. Gardner Ph.D. (Plant and Soil Sciences) for discussing her research project for the cultivation of Chinese herbs in America and for providing a reprint ahead of publication of her paper on this topic, Peg Schafer of Chinese Medicinal Herb Farm (Petaluma, California) for authoring the book "The Chinese

Medicinal Herb Farm: A Cultivator's Guide to Small-Scale Organic Herb Production", and Jeff Carpenter of Zack Woods Herb Farm (Hyde Part, Vermont), co-author of the forthcoming book "The Organic Medicinal Herb Farm", for sharing his manuscript ahead of publication and for the stimulating conversations on the concepts of geo-authenticity and the movement by young American farmers to introduce and cultivate non-native high-value medicinal plant crops for the domestic market.

CONFLICT OF INTEREST

The author declares no financial/commercial conflicts of interest.

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