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Revisiting traditional Chinese materia medica from European historical collections and perspective for current use

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ABSTRACT

Background and aim: Chinese Materia Medica (CMM) is subject to changes over time. Investigating changes in botanical ingredients, applications, plant parts used as well as name changes over time, contribute to the understanding of the history and development of CMM.
Materials and methods: This study compares four historic collections of CMM, located in Europe, compiled between 1700 and the late 19th century, with a list of contemporary CMM marketed in Europe.
Results: More than 1700 specimens within these five collections. The dominant families are Fabaceae (5.3–7.2%) and Asteraceae (4.1–5.7%), while half of the medicinal parts are represented by roots or rhizomes and fruits and/or seeds. Their importance has been stable in a time span of 300 years. The proportion of animal and mineral drugs gradually decreased over time. 14 plant species appeared in all five collections. A total of 47 species are shared between the three more recent collections and the modern trade list. Among these common species, most medicinal parts remain unchanged, but for several species the used plant parts changed or new medicinal plant parts appeared. All common species have unanimously been used in ancient classical TCM formulae and/or Chinese patent medicines.
Conclusions: Over more than 300 years, the main body of CMM has hardly changed, with regard to plant taxa and plant parts used. The most prominent changes are related to conservation issues of threatened species, health safety and the discovery of new pharmacological applications of well-known species. Analyzing physical specimens from historic CMM collections complements literature-based research.

1. Introduction

Chinese materia medica (CMM) has been used for thousands of years for traditional medicine in China. The nature and use of CMM have been extensively documented for centuries, with the first record dating from 1100 BC (*Formulae for 52 kinds of disorders*, 五十二病方wǔ shí èr bìng fāng), followed by works such as *the Divine Husbandman's Herbal Foundation Canon* (神农本草经 shén nóng běn cǎo jīng) (200–250 AD), the *Newly Revised Materia Medica* (新修本草 xīn xiū běn cǎo) (650 AD) and the *Compendium of Materia Medica* (本草纲目 běn cǎo gāng mù) from 1578 AD.[1,2] During the millennia of practice, most CMM have remained the same, although some changes have taken place with regard to the botanical source material and medicinal parts.[3,4] Research on the historical changes in CMM reveals the development of Traditional Chinese Medicine (TCM) and the habit of drug usage, which will lead toward a better understanding of the safe and effective use of CMM. Most previous research on historical changes has focused on CMM monographs and literature, and has been well summarized in Chinese publications.[5,6] With the development of textual research on the history of

Abbreviations: CMM, Chinese materia medica; TCM, traditional Chinese medicine; ChP 2015, Chinese Pharmacopoeia 2015 edition.

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CMM, the confusion of many frequently used drugs has been clarified. However, due to the excessive reliance on ancient literature, instead of on physical CMM samples, some conclusions are controversial, and confusion about botanical sources[7] and vernacular names[4] of medicinal plants still exist.

Early CMM collections provide valuable material evidence on historical changes, which is more intuitive and persuasive than textual research. Besides, analyzing physical specimens from pre-modern CMM collections complement literature-based research. However, few studies based on historic CMM collections are published. One of the main reasons for this is that the number of well-preserved, early CMM collections is limited, especially in China, where most of the research on TCM is carried out.

In Europe, the use of herbal medicine also has a long history and has been relatively well documented in herbals and, since the 1550s, in herbaria. From ancient Greece and Rome, the works of Theophrastus's *Historia Plantarum* (c. 300 BC) and Dioscorides's *De Materia Medica* (c. 65 AD), and their many translations and additions, have served for centuries as the major sources of knowledge on herbal medicine. In the Renaissance, scholars reexamined these classical works and published high-quality manuals of medicinal plants[8,9] and the first book herbaria with actual specimens.[10,11] Since the 16th century, the European fleet reached southeast Asia and China, after which economic, cultural and material exchanges have increased significantly. The European interest in East Asian spices and medicine is represented by botanical voucher specimens,[12] published works[13] and illustrations of exotic materia medica.[14]

CMM was regarded as an exotic novelty, a promising source of medicine and a valuable object of scientific research, and transported to Europe on these merchant ships. One famous example is the "China root", the tuber-like rhizomes of *Smilax glabra* Roxb. (Smilacis Glabrae Rhizoma, 土茯苓 tǔ fú líng). China root was described in 1535 as a wonder drug by the Dutch merchant, trader and historian Jan Linschoten, because of its effectiveness in ameliorating symptoms of syphilis.[15] For centuries, travelers and colonial staff stationed in the East collect Chinese medicinal plant products for curiosity, which has resulted in several pre-modern CMM collections preserved in museums in Europe, such as in the Sloane Collection in Natural History Museum in London,[16] the Westhoff Collection in the Utrecht University Museum[4] and the Hooper Collection in Royal Botanic Gardens Kew.[3] These valuable historical CMM collections provide the most direct physical basis for research on the historical changes and development of CMM, and can fill the gap between the body of textual research and studies on physical specimens.

In this study, we compared several historical and contemporary CMM collections located in Europe with more than a 300-year time span (three pre-modern and one modern CMM collections) to a list of currently commercialized CMM by a Chinese company in the Netherlands. We posed the following research questions:

1. Is the botanical identity of CMM products stable over time?
2. Does the medicinal plant part of these species change over time?
3. Which species are shared by all CMM collections and why?
4. Are there CMM species that disappeared over time?
5. Are there species that recently emerged as CMM?

By comparing the similarities and differences in the five CMM collections, our research results will contribute to a better understanding of the 'evolution' of Chinese herbal medicine, which will help to better evaluate the safety and effective use of CMM use.

2. Materials and methods

2.1. Collections studied

We studied four historical CMM collections (Fig. 1) and compared these to a list of CMM from the commercial trader Zhong Hua International Trading B.V. (https://www.zhonghua-trading.com), located in Utrecht, the Netherlands. This company is one of the major players in the import and export of Chinese herbal medicine on the European market.

The oldest collection that we included in our analysis is preserved at the Natural History Museum in London, UK. It is part of the Hans Sloane Collection, and thus herein referred to as the 'Sloane collection', and is approximately 320 years old. This CMM collection has been studied in detail by Zhao et al.,[16] so for our analysis, we retrieved the pharmaceutical names, plant parts and scientific names from their published article. Zhao et al.[16] counted 84 specimens in the Sloane Collection, of which 76 were plant materials, but several could not be identified to species level (Table 1, Appendices 1, tab 'Sloane').

The Westhoff Collection is housed by the Utrecht University Museum (Utrecht, the Netherlands). This collection was acquired from Indonesia by Dr. C.H.A Westhoff around 1882. It contains 395 specimens, of which 314 are plant-based (Table 1, Appendices 1, tab 'Westhoff').

Details about the species, plant parts and Chinese names of the Westhoff Collection were published previously by Jia et al.[4] Similar to the Sloane collection, several specimens lost their identifiable characteristics due to long-term storage.

The Hooper collection is stored in the Economic Botany Collection of the Royal Botanic Gardens Kew, UK. It was acquired from Chinese pharmacies in Malaya by the botanist Isaac Henry Burkill (1870–1965). Hooper conducted the first identifications of this collection, and therefore referred to as the Hooper Collection.[17] Brand et al.[3] recently revised the specimen identifications within the Hooper Collection, and for our analysis, we used their results with regard to plant parts and botanical taxa. Among the 619 specimens identified by Brand et al.,[3] there were many duplicates (identical taxa and plant parts, for example EBC# 69076 and EBC# 69210, see Appendices 1, tab 'Hooper 619'). In this study, we wanted to compare the botanical composition, so these identical specimens were counted only once. After removing 99 redundancies, 520 specimens in Hooper Collection were included in our analysis. Of these 520 specimens, 493 are plant materials (Table 1, Appendices 1, tab 'Hooper 520').

The Catlender Collection is a private collection held by Dr. C.M. Catlender in Leiden, the Netherlands. It is between 20 and 30 years old and contains 297 specimens, of which 247 are plant-based materials (Table 1, Appendices 1, tab 'Catlender'). To see how many of the historically used Chinese plant taxa continue to be part of the commercialized body of CMM today, we compared the taxa in the historic collections to the 2021 species trade list obtained from Zhong Hua International Trading B.V. in Utrecht (https://www.zhonghua-trading.com), wholesaler in traditional Chinese medicine on the European market. Their product list contained 333 drug names, of which 295 represent plant-based medicine (Table 1, Appendices 1, tab 'Zhong Hua').

2.2. Species identification

Several selection criteria were applied in our comparison of botanical species within these five collections. Excluded from our analysis were 1) unidentified specimens; 2) CMM specimens with multiple botanical sources that could not be identified on species level based on morphological features; 3) zoological and mineral

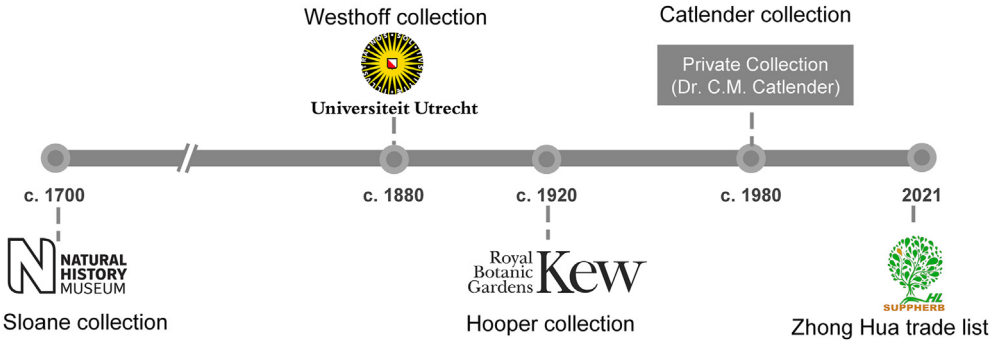

Fig. 1. The four historical collections of Chinese materia medica in chronological order, and the trade list of contemporary marketed CMM.

Table 1
Number of specimens and their natural origin in the five studied collections.

CMM collection		Sloane Collection	Westhoff Collection	Hooper Collection	Catlender Collection	Zhong Hua Trade list
		(c. 1700)	(c. 1880)	(1924)	(c. 1980)	(2021)
Total amount of specimens		84	395	520	297	333
Material origin	Plant[a]	76	314	493	247	295
	Animal[a]	3	36	1	20	16
	Mineral[a]	1	34	2	15	11
	Fungi	2	2	13	10	8
	Other	2	9[b]	11[b]	5	3

[a] And related substances.
[b] Including unidentified specimens.

substances. If different parts of the same plant species were used as separate medicinal products, the species itself was only counted once.

To verify the botanical identity, nomenclature and plant parts represented by the specimens, we used the specification of the Chinese Pharmacopoeia 2015 edition (ChP 2015),[18] Zhong Hua Ben Cao (中华本草 zhōng huá běn cǎo)[19] and Zhong Yao Da Ci Dian (中药大辞典 zhōng yào dà cí diǎn).[20] For current scientific names, we followed the Plants of the World Online database (http://powo.science.kew.org/) and the Flora of China.[21] To verify the use of the species shared by the five CMM collections in TCM formulae, we consulted the formulae of Chinese patent medicine[18] and the ancient classical TCM formulae list issued by the Chinese National Administration of Traditional Chinese Medicine (http://kjs.satcm.gov.cn/zhengcewenjian/2018-04-16/7107.html). A Venn diagram was created to show similarities and differences among the four collections and the currently traded CMM, using the webtool Venn (http://bioinformatics.psb.ugent.be/webtools/Venn/). The UpSet plots were made with the OECloud tools (https://cloud.oebiotech.cn).

3. Results and discussion

3.1. Variation in natural origin of specimens

Our final database contained more than 1700 specimens, retrieved from the publications on the three historical CMM collections, our revision of the Catlender collection and the Zhong Hua list of currently commercialized herbal medicine (Appendix 1). Although the age and provenances of the CMM collections were quite different, the largest proportion of the specimens was always plant-based (Table 1). Some clear differences were visible in the proportion of CMM of animal and mineral origin among the collections. The Sloane collection was small (84 specimens) and contained three animal-based and one mineral specimen, while the Hooper collection did not contain animal and mineral drug.[3] In the other three collections, the number of animal-based drugs decreased over time: from 9.1% of the specimens in the Westhoff collection to 6.7% in the Catlender collection and 4.8% in the Zhong Hua list (Table 1). The mineral drugs also decreased from 8.6% of the specimens in the Westhoff collection to 5.1% in the Catlender collection and 3.3% in Zhong Hua's list. The reason for this may lie in the conservation issues concerning species of animals threatened by the trade in Chinese medicine. For example, pangolin scales (Mantitis Squama, 穿山甲 chuān shān jiǎ, *Manis pentadactyla* L.) are commonly used in China to promote lactation in women and reduce swelling (ChP 2015). Pangolin scales were present in the Westhoff and Catlender collections, but absent from the Zhong Hua list in 2021, because pangolins are endangered and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) transferred all eight species of pangolin from Appendix II to I in 2016.[22] In 2020, the Chinese Pharmacopoeia Commission also removed pangolin scales from the Chinese Pharmacopoeia. Although pangolin scales are still illegally traded and consumed as medicine in China,[23] the absence of pangolin scales in the list of commercial CMM in Europe illustrates the efforts of European environmental organizations, CITES and European law.

3.2. Variation in plant families

When we categorized the plant medicine on family level, the collections showed a clear tendency in botanical composition (Table 2). The most represented plant family in all five CMM collections was the Fabaceae, representing 5.3%–7.2% of the specimens. The second largest family was the Asteraceae (4.1%–5.7% of the specimens), except for the Sloane Collection, in which Rutaceae were more abundant than Asteraceae. Compared to the other four collections, the Sloane Collection was much smaller with only 84 specimens, so possible less representative of the botanical diversity in CMM used around 1700. The Asteraceae still accounted for 4.8%

Table 2
Comparison of 5 CMM collections in plant family. Similar colours represent similar families.

Sloane (84 specimens) (c. 1700)		Westhoff (395 specimens) (c. 1880)		Hooper (520 specimens) (1924)		Catlender (297 specimens) (c. 1980)		Zhong Hua (333 specimens) (2021)	
Family	Quantity (%)	Family	Quantity (%)	Family	Quantity (%)	Family	Quantity (%)	Family	Quantity (%)
Fabaceae	6 (7.1%)	Zoological substance	36 (9.1%)	Fabaceae	31 (6.0%)	Fabaceae	20 (6.7%)	Fabaceae	24 (7.2%)
Rutaceae	5 (6.0%)	Mineral	34 (8.6%)	Asteraceae	28 (5.4%)	Zoological substance	20 (6.7%)	Asteraceae	19 (5.7%)
Asteraceae	4 (4.8%)	Fabaceae	21 (5.3%)	Apiaceae	27 (5.2%)	Asteraceae	17 (5.7%)	Rosaceae	16 (4.8%)
Lamiaceae	4 (4.8%)	Asteraceae	16 (4.1%)	Rosaceae	20 (3.8%)	Mineral	15 (5,1%)	Zoological substance	16 (4.8%)
Apiaceae	3 (3.6%)	Lamiaceae	16 (4.1%)	Rutaceae	20 (3.8%)	Apiaceae	14 (4.7%)	Lamiaceae	15 (4.5%)
Brassicaceae	3 (3.6%)	Unidentified	16 (4.1%)	Zingiberaceae	16 (3.1%)	Lamiaceae	13 (4.4%)	Apiaceae	13 (3.9%)
Cucurbitaceae	3 (3.6%)	Apiaceae	13 (3.3%)	Lamiaceae	16 (3.1%)	Rosaceae	11 (3.7%)	Poaceae	13 (3.9%)
Liliaceae	3 (3.6%)	Rosaceae	13 (3.3%)	Araceae	14 (2.7%)	Rutaceae	11 (3.7%)	Rutaceae	12 (3.6%)
Zingiberaceae	3 (3.6%)	Rutaceae	13 (3.3%)	Fungi, seaweeds	13 (2.5%)	Fungi, seaweeds	10 (3.4%)	Mineral	11 (3.3%)
Zoological substance	3 (3.6%)	Zingiberaceae	11 (2.8%)			Poaceae	9 (3.0%)		
Other	47 (56.0%)	Other	206 (52.2%)	Other	335 (64,4%)	Other	157 (52,9%)	Other	194 (58.3%)

of the specimens. The families Apiaceae, Rosaceae, Lamiaceae and Rutaceae were relatively abundant in all five collections (Table 2). Fabaceae and Asteraceae are among the most species-rich plant families in the world. In China, there are 1673 species of Fabaceae and 2336 species of Asteraceae.[21] Because of their high species diversity and their known pharmacological activity,[24–26] more taxa within the Fabaceae and Asteraceae are used as medicine than in other plant families. The comprehensive CMM monograph of Zhong Hua Ben Cao lists 7921 plant-based drugs, 559 belong to the Fabaceae family (7.1% of all plant-based drugs) and 420 drugs from the Asteraceae family (5.3%).[19] These percentages are similar in the CMM collections we studied: Fabaceae and Asteraceae are major sources of medicinal plants. However, these families are not dominant and never represent more than 10% of the floristic diversity: the low percentages indicate that the plant sources of CMM are highly diverse.

3.3. Plant parts represented in CMM collections

With regard to the medicinal parts, roots and/or rhizomes, fruits and/or seeds are the dominant plant organs in all collections (Table 3). This has been stable in a time span of 300 years, as roots/rhizomes, fruits and seeds together account for about 50% of the specimens in all collections. CMM that is represented by entire herbs account for 8–11% of the specimens in each collection, except for Hooper collection, where only 2.9% of the specimens are whole herbs. This may be caused by the considerable number of unidentified specimens, which were left out of our analysis. No leaf-based drugs were found in the Sloane Collection, but this can be explained by the small size of this collection.

From an overall perspective, the composition of botanical families and medicinal parts show a remarkable continuity over a 300-year time span.

3.4. Changes and continuities in species over time

With regard to plant families and medicinal parts, the CMM collections clearly show continuity, but differences in botanical species could indicate subtle changes in Chinese herbal medicine use over time. Species that are present in all four studied collections and the modern trade list could be considered as stable elements in Chinese medicine over the past centuries. In contrast, plant taxa that only appear in one or two of the historic collections may have lost their importance in Chinese medicine today. Fig. 2 shows the number of common and unique species among the four collections and the modern trade list. As not all specimens were identified to species level in the collections, the number of species that we could compare was considerably lower than the number of specimens in each collection.

3.5. Popular CMM species over time

There are 14 plant species that appeared in all five collections (Fig. 2B, far right). Their Chinese pharmaceutical and scientific names, medicinal parts and pharmaceutical names are listed in Table 4. Although the medicines have identical botanical sources, the used parts are not always the same: the root of *Reynoutria multiflora* (Thunb.) Moldenke (Polygoni Multiflori Radix, 何首乌 hé shǒu wū) is always present, but the vine with leaves of this species is only included in the modern Catlender collection and Zhong Hua trade list. The use of the root (Polygoni Multiflori Radix) and the stem with leaves (Polygoni Multiflori Caulis, 夜交藤 yè jiāo téng) of

Table 3
Medicinal plant parts in the 4 CMM collections and the modern trade list. Similar colours represent the same plant organ.

Sloane (84 specimens) (c. 1700)		Westhoff (395 specimens) (c. 1880)		Hooper (520 specimens) (1924)		Catlender (297 specimens) (c. 1980)		Zhong Hua (333 specimens) (2021)	
Medicinal part	Quantity (%)	Medicinal part	Quantity (%)	Medicinal part	Quantity (%)	Medicinal part	Quantity (%)	Medicinal part	Quantity (%)
Fruits / seeds	32 (38.1%)	Roots / rhizomes	108 (27.3%)	Roots / rhizomes	135 (26.0%)	Roots / rhizomes	89 (30.0%)	Roots / rhizomes	101 (30.3%)
Roots / rhizomes	21 (25.0%)	Fruits / seeds	86 (21.8%)	Fruits / seeds	121 (23.3%)	Fruits / seeds	77 (25.9%)	Fruits / seeds	90 (27.0%)
Whole herbs	7 (8.3%)	Whole herbs	38 (9.6%)	Unidentified	81 (15.6%)	Whole herbs	29 (9.8%)	Whole herbs	38 (11.4%)
Flowers	5 (6.0%)	Zoological substance	36 (9.1%)	Stems / wood	66 (12.7%)	Zoological substance	20 (6.7%)	Flowers	18 (5.4%)
Stems / wood	5 (6.0%)	Minerals	34 (8.6%)	Flowers	37 (7.1%)	Minerals	15 (5.1%)	Stems / wood	18 (5.4%)
Bark	4 (4.8%)	Stems and woods	25 (6.3%)	Bark	23 (4.4%)	Stems / wood	14 (4.7%)	Bark	16 (4.8%)
Zoological substance	3 (3.6%)	Flowers	19 (4.8%)	Leaves	18 (3.5%)	Bark	13 (4.4%)	Zoological substance	16 (4.8%)
Resins	2 (2.4%)	Bark	14 (3.5%)	Whole herb	15 (2.9%)	Flowers	13 (4.4%)	Leaves	12 (3.6%)
Fungi, seaweeds	2 (2.4%)	Leaves	6 (1.5%)	Fungi, seaweeds	13 (2.5%)	Fungi, seaweeds	10 (3.4%)	Minerals	11 (3.3%)
Minerals	1 (1.2%)	Fungi, seaweeds	4 (1.0%)	Resins	6 (1.2%)	Leaves	8 (2.7%)	Fungi, seaweeds	8 (2.4%)
Other	2 (2.4%)	Other	25 (6.3%)	Other	5 (1.0%)	Other	9 (3.0%)	Other	5 (1.5%)

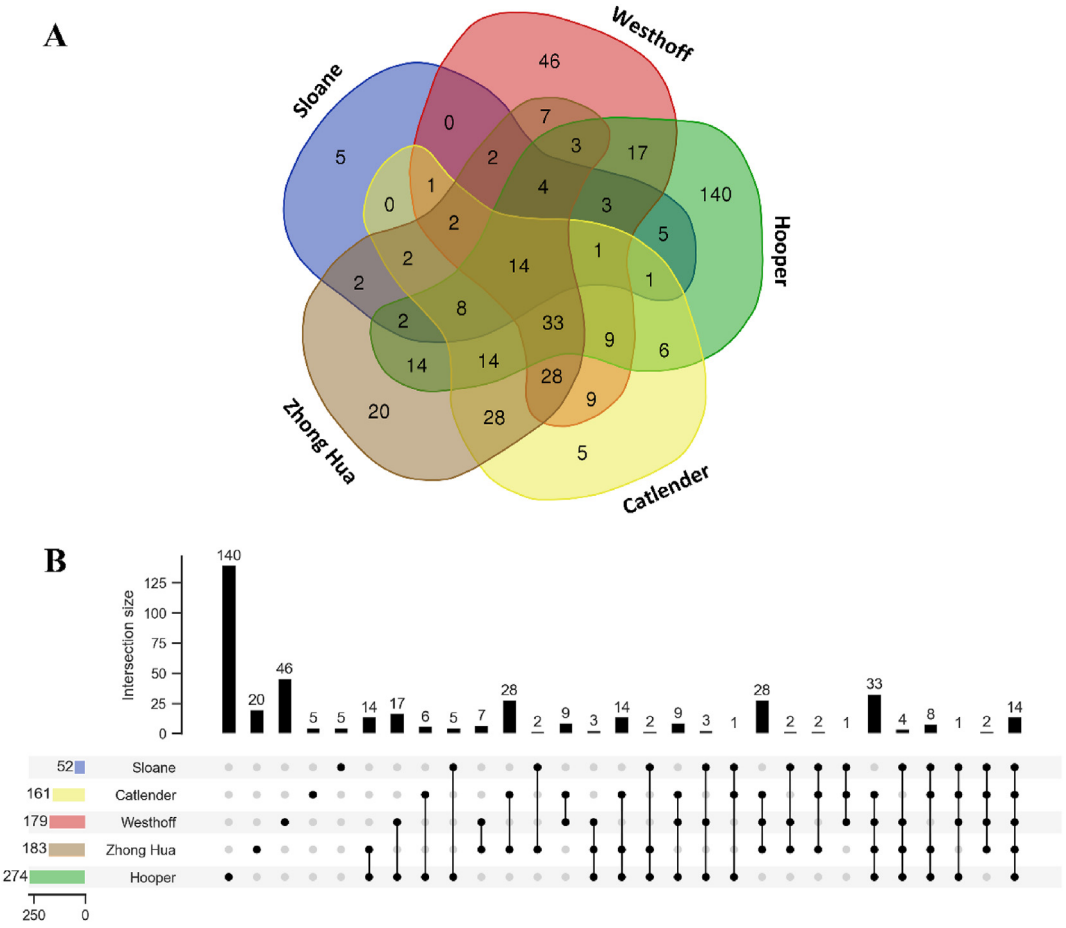

Fig. 2. Similarities and differences in species between the four CMM collections and the modern trade list. A. Venn diagram showing the number of overlapping species. B. UpSet plots: single dots without connecting lines representing unique species in each corresponding collection. The upper column indicates the number of unique species. Dots connected with line indicate overlapping species between these specific collections, with the number of overlapping species.

this species as medicine can be traced back to the 10th century (Ri Hua Zi Materia Medica, 日华子本草, rì huá zǐ běn cǎo) and the 17th century (Ben Jing Feng Yuan, 本经逢原 běn jīng féng yuán). Records on the use of these roots in traditional Chinese medicine formulae also date back to the 15th century (Prescriptions for Universal Relief, 普济方 pǔ jì fāng, 1406). In contrast, most formulae that use the vine with leaves as an ingredient have only appeared in the 1970s–1980s.[19,20] The appearance of the stem and leaves of *R. multiflora* in the Catlender collection demonstrates the recent changes in use of this frequently employed plant, which is again confirmed by the modern trade list. Table 4 also shows that for the species *Citrus* × *aurantium* L. and *Nelumbo nucifera* Gaertn., much more parts are used nowadays than in the past. For the other shared species, the plant parts employed in medicine did not change over time.

As the Sloane Collection is dissimilar to other collections due to its small sample size, we made another comparison on species overlap within the other three collections (Westhoff, Hooper and Catlender) and the Zhong Hua 2021 trade list. The number of common species increased to 47 (Table 5), but the exact uses of the species showed some variation over time. One interesting example is *Dimocarpus longan* Lour. In the Westhoff and Hooper collections, the flowers (Longan Flos, 龙眼花 lóng yǎn huā) are used as medicine, but in the Catlender collection and Zhong Hua list, the medicinal part is the aril around the seed (Longan Arillus, 龙眼肉 lóng yǎn ròu). The aril, however, has a long history of medicinal use in China, appearing as one of the main ingredients in various TCM formulae (Ji Sheng Fang, 济生方 jì shēng fāng, 1253; Jing Yue Quan Shu, 景岳全书 jǐng yuè quán shū,1624) as well as in present Chinese patent medicine.[18,19] The references on the use of the flowers as medicine are very limited and all come from local monographs of the Fujian province.[19,20] These findings again support the previous conclusions that the Sloane and Westhoff collections are originally from southeast China.[3,4] These differences in used plant parts among the collections reflect alterations in herbal medicine applications but also show regional variation in traditional Chinese Medicine.

Another species that all four collections have in common, *Rosa laevigata* Michx., also witnessed an extension of its medicinal parts. The fruit of *R. laevigata* (Rosae Laevigatae Fructus, 金樱子 jīn yīng zǐ) is included in the three collections, but in the Zhong Hua 2021 trade list, not only the fruit but also the root of *R. laevigata* (Rosae Laevigatae Radix, 金樱根 jīn yīng gēn) is present. *R. laevigata* roots only recently appeared in TCM formulae and Chinese patent medicines,[18–20] which is reflected in our comparative study as the CMM collection of the 1980s did not yet show this change.

China root, *Smilax glabra* Roxb. (Smilacis Glabrae Rhizoma, 土茯苓 tǔ fú líng), as we mentioned in Introduction part, was quite popular in Europe since 16th century.[15] Unsurprisingly, it has been found in historical collections and Zhong Hua list (except Westhoff collection), which supports the conclusion drew from textual research and complement them from physical specimen aspect.

Table 4
Common species appeared in 5 collection.

Scientific name	Sloane Collection (c. 1700)		Westhoff Collection (c. 1880)		Hooper Collection (1924)		Catlender Collection (c. 1980)		Zhong Hua trade list (2021)	
	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)
Achyranthes bidentata Blume	Root	Achyranthis Bidentatae Radix (牛膝)	Root	Achyranthis Bidentatae Radix Praeparata (酒淮膝)	Root	Achyranthis Bidentatae Radix (牛膝)	Root	Achyranthis Bidentatae Radix (牛膝)	Root	Achyranthis Bidentatae Radix (牛膝)
					Stem	unknow				
Areca catechu L.	Seed	Arecae Semen (槟榔)	Seed	Arecae Semen (槟榔)	Seed	Arecae Semen (槟榔)	Seed	Arecae Semen (槟榔)	Seed	Arecae Semen (槟榔)
			Pericarp	Arecae Pericarpium (大腹皮)			Pericarp	Arecae Pericarpium (大腹皮)	Pericarp	Arecae Pericarpium (大腹皮)
Citrus × aurantium L.	Fruit	Aurantii Fructus (枳壳)	Fruit	Aurantii Fructus Immaturus Praeparata (炒枳实)	Sliced peel	unknow	Fruit	Aurantii Fructus (枳壳)	Fruit	Aurantii Fructus (枳壳)
	Pericarp	Citri Reticulatae Pericarpium (陈皮)	Exocarp	Citri Reticulatae Exocarpium (橘红)	Flower	Citri Aurantii Flos (玳玳花)	Fruit	Aurantii Fructus Immaturus (枳实)	Fruit	Aurantii Fructus Immaturus (枳实)
			Pericarp	Citri Reticulatae Pericarpium Viride (青皮)			Seed	Citri Reticulatae Semen (橘核)	Seed	Citri Reticulatae Semen (橘核)
			Pericarp	Citri Reticulatae Pericarpium (四陈皮)			Exocarp	Citri Reticulatae Exocarpium (橘红)	Exocarp	Citri Reticulatae Exocarpium (橘红)
							Pericarp	Citri Reticulatae Pericarpium Viride (青皮)	Pericarp	Citri Reticulatae Pericarpium Viride (青皮)
							Pericarp	Citri Reticulatae Pericarpium (陈皮)	Pericarp	Citri Reticulatae Pericarpium (陈皮)
Gardenia jasminoides J.Ellis	Fruit	Gardeniae Fructus (栀子)	Fruit	Gardeniae Fructus (山栀子)	Fruit	Gardeniae Fructus (栀子)	Fruit	Gardeniae Fructus (栀子)	Fruit	Gardeniae Fructus (生栀子)
			Fruit	Gardeniae Fructus Praeparata (黑枝仁)					Fruit	Gardeniae Fructus Praeparata (炒栀子)
Leonurus japonicus Houtt.	Whole herb	Leonuri Herba (益母草)	Fruit	Leonuri Fructus (茺蔚子)	Whole herb	Leonuri Herba (益母草)	Whole herb	Leonuri Herba (益母草)	Whole herb	Leonuri Herba (益母草)
					Fruit	Leonuri Fructus (茺蔚子)			Fruit	Leonuri Fructus (茺蔚子)
Lonicera japonica Thunb.	Flower	Lonicerae Japonicae Flos (金银花)	Flower	Lonicerae Japonicae Flos (金银花)	Flower	Lonicerae Japonicae Flos (金银花)	Flower	Lonicerae Japonicae Flos (金银花)	Flower	Lonicerae Japonicae Flos (金银花)
			Vine	Lonicerae Japonicae Caulis (忍冬藤)					Vine	Lonicerae Japonicae Caulis (忍冬藤)
Nelumbo nucifera Gaertn.	Rhizome	Nelumbinis Rhizomatis Nodus (藕节)	Rhizome	Nelumbinis Rhizomatis Nodus (粉藕节)	Rhizome	Nelumbinis Rhizomatis Nodus (藕节)	Rhizome	Nelumbinis Rhizomatis Nodus (藕节)	Rhizome	Nelumbinis Rhizomatis Nodus (生藕节)
			Rhizome	Nelumbinis Nodus Rhizomatis Praeparata (黑藕节)	Stamen	Nelumbinis Stamen (莲须)	Stamen	Nelumbinis Stamen (莲须)	Rhizome	Nelumbinis Nodus Rhizomatis Praeparata (炭藕节)
			Stamen	Nelumbinis Stamen (金莲须)	Seed	Nelumbinis Semen (莲子)	Seed	Nelumbinis Semen (莲子)	Seed	Nelumbinis Semen (莲子)
			Seed	Nelumbinis Semen (莲子)	Flower	Nelumbinis Flos (莲花)	Leaf	Nelumbinis Folium (荷叶)	Leaf	Nelumbinis Folium (荷叶)
									Receptacle	Nelumbinis Receptaculum (莲房)
									Plumule	Nelumbinis Plumuia (莲子芯)
Nepeta tenuifolia Benth.	Whole herb	Schizonepetae Herba (荆芥)	Whole herb	Schizonepetae Herba (荆芥)	Flower	Schizonepetae Spica (荆芥穗)	Whole herb	Schizonepetae Herba (荆芥)	Whole herb	Schizonepetae Herba (荆芥)
			Whole herb	Schizonepetae Herba Praeparata (黑荆芥)						
Polygonatum odoratum (Mill.) Druce	Rhizome	Polygonati Odorati Rhizoma (玉竹)	Rhizome	Polygonati Odorati Rhizoma (明玉竹)	Rhizome	Polygonati Odorati Rhizoma (玉竹)	Rhizome	Polygonati Odorati Rhizoma (玉竹)	Rhizome	Polygonati Odorati Rhizoma (玉竹)

(*continued on next page*)

Table 4 (*continued*)

Scientific name	Sloane Collection (c. 1700)		Westhoff Collection (c. 1880)		Hooper Collection (1924)		Catlender Collection (c. 1980)		Zhong Hua trade list (2021)	
	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)
Prunus mume (Siebold) Siebold & Zucc.	Fruit	Mume Fructus (乌梅)	Fruit	Mume Fructus (乌梅)	Fruit	Mume Fructus (乌梅)	Fruit	Mume Fructus (乌梅)	Fruit	Mume Fructus (乌梅)
					Kernel	Mume Semen (梅核仁)				
Raphanus raphanistrum subsp. sativus (L.) Domin	Seed	Raphani Semen (莱菔子)	Seed	Raphani Semen (莱菔子)	Seed	Raphani Semen (莱菔子)	Seed	Raphani Semen (莱菔子)	Seed	Raphani Semen (莱菔子)
Reynoutria multiflora (Thunb.) Moldenke	Root	Polygoni Multiflori Radix (何首乌)	Root	Polygoni Multiflori Radix Praeparata (制首乌)	Root	Polygoni Multiflori Radix (何首乌)	Root	Polygoni Multiflori Radix (何首乌)	Root	Polygoni Multiflori Radix (何首乌)
							Vine with leaves	Polygoni Multiflori Caulis (夜交藤)	Root	Polygoni Multiflori Radix Praeparata (制首乌)
									Vine with leaves	Polygoni Multiflori Caulis (夜交藤)
Salvia miltiorrhiza Bunge	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma (丹参)	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma Praeparata (酒丹参)	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma (丹参)	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma (丹参)	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma (丹参)
Syzygium aromaticum (L.) Merr. & L.M.Perry	Flower	Caryophylli Flos (丁香)	Flower	Caryophylli Flos (丁香末)	Flower	Caryophylli Flos (丁香)	Flower	Caryophylli Flos (丁香)	Flower	Caryophylli Flos (公丁香)

Except for the common species discussed before, there are several common drugs in the five collections that are likely to come from multiple botanical sources. Glycyrrhizae Radix et Rhizoma (甘草 gān cǎo) can be obtained from *Glycyrrhiza uralensis* Fisch., *G. glabra* L. and *G. inflata* Batal. Ligustici Rhizoma et Radix (藁本 gǎo běn) has two possible botanical sources: *Ligusticum sinense* Oliv. and *L. jeholense* (Nakai & Kitag.) Nakai & Kitag. Gentianae Macrophyllae Radix (秦艽 qín jiāo) has three botanical sources: *Gentiana macrophylla* Pall., *G. straminea* Maxim., *G. crassicaulis* Duthie ex Burk. and *G. dahurica* Fisch. Finally, Gentianae Radix et Rhizoma (龙胆 lóng dǎn) can be harvested from *Gentiana manshurica* Kitag., *G. scabra* Bge., *G. triflora* Pall. and G. rigescens Franch.[18] These CMM products all appear over more than 300 years, but as the exact species from which they were harvested is not known or visible in the morphology of the product, we could not include these species in our comparative analysis.

If we focused on the large collections and exclude the smallest and oldest Sloane collection, more common drugs emerge. Bupleuri Radix (柴胡chái hú, botanical sources: *Bupleurum chinense* DC. and *B. scorzonerifolium* Willd.), Dianthi Herba (瞿麦qú mài, botanical sources: *Dianthus chinensis* L. and *D. superbus* L.) and Cassiae Semen (决明子jué míng zǐ, botanical sources: *Senna obtusifolia* (L.) H.S.Irwin & Barneby and *S. tora* (L.) Roxb.) are shared between the remaining three collections and the modern trade list. These drugs have been used for thousands of years and are still very frequently used in China.[18–20]

Among the studied collections, two common drugs, Aristolochiae Fructus (马兜铃mǎ dōu líng, botanical sources: *Aristolochia contorta* Bunge and *A. debilis* Siebold & Zucc.) and Asari Radix et Rhizoma (细辛xì xīn, botanical sources: *Asarum heterotropoides* F.Schmidt and *A. sieboldii* Miq.) also attracted our attention. These two products are present in four historical collections but disappeared from the list of currently commercialized CMM (Zhong Hua collection 2021). *Aristolochia* fruits and *Asarum* roots belong to the Aristolochiaceae family, well known because of its toxic aristolochic acids.[27,28] These components are reported to stimulate defense mechanisms against infections and inflammation in several mammalian species, including humans (European Medicines Evaluation Agency, 2005). In the past, *Aristolochia* fruits and *Asarum* roots were frequently used in traditional Chinese Medicine. After several accidents with poisoning,[29,30] there is a better understanding of the toxicity of aristolochic acids, and species within the Aristolochiaceae family have been restricted or prohibited as herbal medicine in Europe.[31] The recent exclusion of Aristolochiaceae species in CMM traded in Europe is also reflected in our comparative analysis.

3.6. Common species used in TCM formulae

In TCM, instead of single component medicines, combinations of multiple herbs are generally used for clinical treatment. These multi-herbal mixtures are known as formulae. More than 100,000 different TCM formulae have been documented over the past 2000 years.[32] Many of these classic formulae of Chinese patent medicine documented in the ChP 2015 have been extensively studied for efficacy and safety, and are widely used by the general public as over-the-counter (OTC) drugs in China today. The ancient classical TCM formulae are described in well-known historical CMM monographs, such as Treatise on Febrile Diseases (伤寒论shāng hán lùn) and Synopsis of the Golden Chamber (金匮要略 jīn guì yào lüè) compiled by Zhang Zhongjing, Thousand Ducat Formulas for Emergencies (备急千金要方bèi jí qiān jīn yào fāng) compiled by Sun Simiao.[33] Formulae from the Chinese patent medicine in the ChP 2015 and the ancient classical TCM formulae list issued by the

Table 5
Common species appeared in 4 collections.

Scientific name	Westhoff Collection (c. 1880)		Hooper Collection (1924)		Catlender Collection (c. 1980)		Zhong Hua trade list (2021)	
	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)
Achyranthes bidentata Blume	Root	Achyranthis Bidentatae Radix Praeparata (酒淮膝)	Root	Achyranthis Bidentatae Radix (牛膝)	Root	Achyranthis Bidentatae Radix (牛膝)	Root	Achyranthis Bidentatae Radix (牛膝)
			Stem	unknow				
Areca catechu L.	Seed	Arecae Semen (槟榔)	Seed	Arecae Semen (槟榔)	Seed	Arecae Semen (槟榔)	Seed	Arecae Semen (槟榔)
	Pericarp	Arecae Pericarpium (大腹皮)			Pericarp	Arecae Pericarpium (大腹皮)	Pericarp	Arecae Pericarpium (大腹皮)
Citrus × aurantium L.	Fruit	Aurantii Fructus Immaturus Praeparata (炒枳实)	Sliced peel	unknow	Fruit	Aurantii Fructus (枳壳)	Fruit	Aurantii Fructus (枳壳)
	Exocarp	Citri Reticulatae Exocarpium (橘红)	Flower	Citri Aurantii Flos (玳玳花)	Fruit	Aurantii Fructus Immaturus (枳实)	Fruit	Aurantii Fructus Immaturus (枳实)
	Pericarp	Citri Reticulatae Pericarpium Viride (青皮)			Seed	Citri Reticulatae Semen (橘核)	Seed	Citri Reticulatae Semen (橘核)
	Pericarp	Citri Reticulatae Pericarpium (四陈皮)			Exocarp	Citri Reticulatae Exocarpium (橘红)	Exocarp	Citri Reticulatae Exocarpium (橘红)
					Pericarp	Citri Reticulatae Pericarpium Viride (青皮)	Pericarp	Citri Reticulatae Pericarpium Viride (青皮)
					Pericarp	Citri Reticulatae Pericarpium (陈皮)	Pericarp	Citri Reticulatae Pericarpium (陈皮)
Gardenia jasminoides J.Ellis	Fruit	Gardeniae Fructus (山栀子)	Fruit	Gardeniae Fructus (栀子)	Fruit	Gardeniae Fructus (栀子)	Fruit	Gardeniae Fructus (生栀子)
	Fruit	Gardeniae Fructus Praeparata (黑枝仁)					Fruit	Gardeniae Fructus Praeparata (炒栀子)
Leonurus japonicus Houtt.	Fruit	Leonuri Fructus (芜蔚子)	Whole herb	Leonuri Herba (益母草)	Whole herb	Leonuri Herba (益母草)	Whole herb	Leonuri Herba (益母草)
			Fruit	Leonuri Fructus (芜蔚子)			Fruit	Leonuri Fructus (芜蔚子)
Lonicera japonica Thunb.	Flower	Lonicerae Japonicae Flos (金银花)	Flower	Lonicerae Japonicae Flos (金银花)	Flower	Lonicerae Japonicae Flos (金银花)	Flower	Lonicerae Japonicae Flos (金银花)
	Vine	Lonicerae Japonicae Caulis (忍冬藤)					Vine	Lonicerae Japonicae Caulis (忍冬藤)
Nelumbo nucifera Gaertn.	Rhizome	Nelumbinis Rhizomatis Nodus (粉藕节)	Rhizome	Nelumbinis Rhizomatis Nodus (藕节)	Rhizome	Nelumbinis Rhizomatis Nodus (藕节)	Rhizome	Nelumbinis Rhizomatis Nodus (生藕节)
	Rhizome	Nelumbinis Nodus Rhizomatis Praeparata (黑藕节)	Stamen	Nelumbinis Stamen (莲须)	Stamen	Nelumbinis Stamen (莲须)	Rhizome	Nelumbinis Nodus Rhizomatis Praeparata (炭藕节)
	Stamen	Nelumbinis Stamen (金莲须)	Seed	Nelumbinis Semen (莲子)	Seed	Nelumbinis Semen (莲子)	Seed	Nelumbinis Semen (莲子)
	Seed	Nelumbinis Semen (莲子)	Flower	Nelumbinis Flos (莲花)	Leaf	Nelumbinis Folium (荷叶)	Leaf	Nelumbinis Folium (荷叶)
							Receptacle	Nelumbinis Receptaculum (莲房)
							Plumule	Nelumbinis Plumuia (莲子芯)
Nepeta tenuifolia Benth.	Whole herb	Schizonepetae Herba (荆芥)	Flower	Schizonepetae Spica (荆芥穗)	Whole herb	Schizonepetae Herba (荆芥)	Whole herb	Schizonepetae Herba (荆芥)
	Whole herb	Schizonepetae Herba Praeparata (黑荆芥)						
Polygonatum odoratum (Mill.) Druce	Rhizome	Polygonati Odorati Rhizoma (明玉竹)	Rhizome	Polygonati Odorati Rhizoma (玉竹)	Rhizome	Polygonati Odorati Rhizoma (玉竹)	Rhizome	Polygonati Odorati Rhizoma (玉竹)
Prunus mume (Siebold) Siebold & Zucc.	Fruit	Mume Fructus (乌梅)	Fruit	Mume Fructus (乌梅)	Fruit	Mume Fructus (乌梅)	Fruit	Mume Fructus (乌梅)
			Kernel	Mume Semen (梅核仁)				
Raphanus raphanistrum subsp. sativus (L.) Domin	Seed	Raphani Semen (莱菔子)	Seed	Raphani Semen (莱菔子)	Seed	Raphani Semen (莱菔子)	Seed	Raphani Semen (莱菔子)
Reynoutria multiflora (Thunb.) Moldenke	Root	Polygoni Multiflori Radix Praeparata (制首乌)	Root	Polygoni Multiflori Radix (何首乌)	Root	Polygoni Multiflori Radix (何首乌)	Root	Polygoni Multiflori Radix (何首乌)
					Vine with leaves	Polygoni Multiflori Caulis (夜交藤)	Root	Polygoni Multiflori Radix Praeparata (制首乌)
							Vine with leaves	Polygoni Multiflori Caulis (夜交藤)
Salvia miltiorrhiza Bunge	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma Praeparata (酒丹参)	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma (丹参)	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma (丹参)	Root and rhizome	Salviae Miltiorrhizae Radix et Rhizoma (丹参)

(*continued on next page*)

Table 5 (*continued*)

Scientific name	Westhoff Collection (c. 1880)		Hooper Collection (1924)		Catlender Collection (c. 1980)		Zhong Hua trade list (2021)	
	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)
Syzygium aromaticum (L.) Merr. & L.M.Perry	Flower	Caryophylli Flos (丁香末)	Flower	Caryophylli Flos (丁香)	Flower	Caryophylli Flos (丁香)	Flower	Caryophylli Flos (公丁香)
Acorus calamus L.	Rhizome	Acori Tatarinowii Rhizoma (石菖蒲)	Rhizome	Acori Tatarinowii Rhizoma (石菖蒲)	Rhizome	Acori Tatarinowii Rhizoma (石菖蒲)	Rhizome	Acori Tatarinowii Rhizoma (石菖蒲)
Alisma plantago-aquatica L.	Rhizome	Alismatis Rhizoma Praeparata (鹹泽泻)	Rhizome	Alismatis Rhizoma (泽泻)	Rhizome	Alismatis Rhizoma (泽泻)	Rhizome	Alismatis Rhizoma (泽泻)
Alpinia oxyphylla Miq.	Fruit	Alpiniae Oxyphyllae Fructus (益智仁)	Fruit	Alpiniae Oxyphyllae Fructus (益智仁)	Fruit	Alpiniae Oxyphyllae Fructus (益智仁)	Fruit	Alpiniae Oxyphyllae Fructus (益智仁)
Anemarrhena asphodeloides Bunge	Rhizome	Anemarrhenae Rhizoma Praeparata (鹹知母)	Rhizome	Anemarrhenae Rhizoma Praeparata (知母)	Rhizome	Anemarrhenae Rhizoma Praeparata (知母)	Rhizome	Anemarrhenae Rhizoma Praeparata (知母)
Artemisia annua L.	Whole herb	Artemisiae Annuae Herba Praeparata (醋青蒿)	Whole herb	Artemisiae Annuae Herba (青蒿)	Whole herb	Artemisiae Annuae Herba (青蒿)	Whole herb	Artemisiae Annuae Herba (青蒿)
Asparagus cochinchinensis (Lour.) Merr.	Root	Asparagi Radix (天文冬)	Root	Asparagi Radix (天门冬)	Root	Asparagi Radix (天门冬)	Root	Asparagi Radix (天门冬)
Carthamus tinctorius L.	Flower	Carthami Flos Praeparata (酒红花)	Flower	Carthami Flos (红花)	Flower	Carthami Flos (红花)	Flower	Carthami Flos (红花)
Citrus medica L.	Pericarp	Citri Sarcodactylis Pericarpium (佛手柑)	Pericarp	Citri Sarcodactylis Pericarpium	Pericarp	Citri Sarcodactylis Fructus (佛手柑)	Fruit	Citri Sarcodactylis Fructus (佛手)
			Flower	Citri Sarcodactylis Flos (佛手花)			Fruit	Citri Fructus (香橼)
Cornus officinalis Siebold & Zucc.	Fruit	Corni Fructus (山茱萸)	Fruit	Corni Fructus (山茱萸)	Fruit	Corni Fructus (山茱萸)	Fruit	Corni Fructus (山茱萸)
Crataegus pinnatifida Bunge	Fruit	Crataegi Fructus (山楂肉)	Fruit	Crataegi Fructus (山楂肉)	Fruit	Crataegi Fructus (山楂)	Fruit	Crataegi Fructus (山楂-生)
							Fruit	Crataegi Fructus Preparata (山楂-焦)
Cullen corylifolium (L.) Medik.	Fruit	Psoraleae Fructus (破故纸)	Fruit	Psoraleae Fructus (补骨脂)	Fruit	Psoraleae Fructus (补骨脂)	Fruit	Psoraleae Fructus (补骨脂)
Curcuma longa L.	Rhizome	Curcumae Longae Rhizoma (姜黄)	Rhizome	Curcumae Longae Rhizoma (姜黄)	Rhizome	Curcumae Longae Rhizoma (姜黄)	Rhizome	Curcumae Longae Rhizoma (姜黄)
			Fruit slices	unknow				
Cyperus rotundus L.	Rhizome	Cyperi Rhizoma Praeparata (四香附)	Rhizome	Cyperi Rhizoma (香附)	Rhizome	Cyperi Rhizoma (香附)	Rhizome	Cyperi Rhizoma (香附)
Dimocarpus longan Lour.	Flower	Longan Flos (龙眼花)	Flower	Longan Flos (龙眼花)	Aril	Longan Arillus (龙眼肉)	Aril	Longan Arillus (龙眼肉)
Eclipta prostrata (L.) L.	Whole herb	Ecliptae Herba (旱莲草)	Whole herb	Ecliptae Herba (旱莲草)	Whole herb	Ecliptae Herba (旱莲草)	Whole herb	Ecliptae Herba (旱莲草)
Foeniculum vulgare Mill.	Fruit	Foeniculi Fructus (小茴香)	Fruit	Foeniculi Fructus (小茴香)	Fruit	Foeniculi Fructus (小茴香)	Fruit	Foeniculi Fructus (小茴香)
Forsythia suspensa (Thunb.) Vahl	Fruit	Forsythiae Fructus (赤连翘)	Fruit	Forsythiae Fructus (连翘)	Fruit	Forsythiae Fructus (连翘)	Fruit	Forsythiae Fructus (连翘)
Gleditsia sinensis Lam.	Thorns	Gleditsiae Spina (皂角刺)	Thorns	Gleditsiae Spina (皂角刺)	Thorns	Gleditsiae Spina (皂角刺)	Thorns	Gleditsiae Spina (皂角刺)
	Fruit	Gleditsiae Fructus (皂荚)	Fruit	Gleditsiae Fructus (皂荚)	Fruit	Gleditsiae Fructus (皂荚)		
Morus alba L.	Root bark	Mori Cortex (桑白皮)	Root bark unknow	Mori Cortex (桑白皮) unknow	Root bark	Mori Cortex (桑白皮)	Root bark	Mori Cortex (桑白皮)
					Fruits	Mori Fructus (桑椹)	Root bark	Mori Cortex Praeparata (炙桑白皮)
					Leaves	Mori Folium (桑叶)	Fruits	Mori Fructus (桑椹)
					Branch	Mori Ramulus (桑枝)	Leaves	Mori Folium (桑叶)
							Branch	Mori Ramulus (桑枝)
Myristica fragrans Houtt.	Seed	Myristicae Semen (肉豆蔻)	Seed	Myristicae Semen (肉豆蔻)	Seed	Myristicae Semen (肉豆蔻)	Seed	Myristicae Semen (肉豆蔻)
Ophiopogon japonicus (Thunb.) Ker Gawl.	Root	Ophiopogonis Radix (麦门冬)	Root	Ophiopogonis Radix (麦门冬)	Root	Ophiopogonis Radix (麦门冬)	Root	Ophiopogonis Radix (麦门冬)
Perilla frutescens (L.) Britton	Fruit	Perillae Fructus (紫苏子)	Fruit	Perillae Fructus (紫苏子)	Fruit	Perillae Fructus (紫苏子)	Fruit	Perillae Fructus (紫苏子)
			Stem	Perillae Caulis (紫苏梗)	Stem	Perillae Caulis (紫苏梗)	Stem	Perillae Caulis (紫苏梗)
			Leaf	Perillae Folium (紫苏叶)	Leaf	Perillae Folium (紫苏叶)	Leaf	Perillae Folium (紫苏叶)
Pinellia ternata (Thunb.) Makino	Rhizome	Pinelliae Rhizoma Praeparata (姜半夏)	Rhizome	Pinelliae Rhizoma (半夏)	Rhizome	Pinelliae Rhizoma (半夏)	Rhizome	Pinelliae Rhizoma (半夏)
Platycladus orientalis (L.) Franco	Leaf	Platycladi Cacumen Praeparata (黑扁柏)	Leaf	Platycladi Cacumen (侧柏叶)	Seed	Platycladi Semen (柏子仁)	Leaf	Platycladi Cacumen (侧柏叶-生)
			Seed	Platycladi Semen (柏子仁)			Leaf	Platycladi Cacumen Praeparata (侧柏叶-炒)
							Seed	Platycladi Semen (柏子仁)

Table 5 (*continued*)

Scientific name	Westhoff Collection (c. 1880)		Hooper Collection (1924)		Catlender Collection (c. 1980)		Zhong Hua trade list (2021)	
	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)	Medicinal part	Pharmaceutical name (Chinese name)
Platycodon grandiflorus (Jacq.) A.DC.	Root	Platycodonis Radix Praeparata (蜜橘梗)	Root	Platycodonis Radix (桔梗)	Root	Platycodonis Radix (桔梗)	Root	Platycodonis Radix (桔梗)
Polygonum aviculare L.	Whole herb	Polygoni Avicularis Herba (萹蓄)	Whole herb	Polygoni Avicularis Herba (萹蓄)	Whole herb	Polygoni Avicularis Herba (萹蓄)	Whole herb	Polygoni Avicularis Herba (萹蓄)
Prunella vulgaris L.	Spike	Prunellae Spica (夏枯草)	Spike	Prunellae Spica (夏枯草)	Spike	Prunellae Spica (夏枯草)	Spike	Prunellae Spica (夏枯草)
Rehmannia glutinosa (Gaertn.) DC.	Root	Rehmanniae Radix (地黄)	Root	Rehmanniae Radix (地黄)	Root	Rehmanniae Radix (地黄)	Root	Rehmanniae Radix (地黄)
	Root	Rehmanniae Radix Praeparata (老熟地)			Root	Rehmanniae Radix Praeparata (熟地黄)	Root	Rehmanniae Radix Praeparata (熟地黄)
Rosa laevigata Michx.	Fruit	Rosae Laevigatae Fructus (大金英)	Fruit	Rosae Laevigatae Fructus (金樱子)	Fruit	Rosae Laevigatae Fructus (金樱子)	Root	Rosae Laevigatae Radix (金樱根)
							Fruit	Rosae Laevigatae Fructus (金樱子)
Saposhnikovia divaricata (Turcz. ex Ledeb.) Schischk.	Root	Saposhnikoviae Radix (软防风)	Root	Saposhnikoviae Radix (防风)	Root	Saposhnikoviae Radix (防风)	Root	Saposhnikoviae Radix (防风)
Xanthium strumarium L.	Fruit	Xanthii Fructus (苍耳子)	Fruit	Xanthii Fructus (苍耳子)	Fruit	Xanthii Fructus (苍耳子)	Fruit	Xanthii Fructus (苍耳子)
Zingiber officinale Roscoe	Rhizome	Zingiberis Rhizoma Praeparata (泡干姜)	Rhizome	Zingiberis Rhizoma (干姜)	Rhizome	Zingiberis Rhizoma (干姜)	Rhizome	Zingiberis Rhizoma (干姜)
Ziziphus jujuba Mill.	Fruit	Jujubae Fructus Praeparata (大乌枣)	Fruit	Jujubae Fructus (大枣)	Fruit	Jujubae Fructus (大枣)	Fruit	Jujubae Fructus (红枣)

Chinese National Administration of Traditional Chinese Medicine can indicate which ingredients were commonly used in the past and present.

The 14 species shared among all four studied collections and the modern trade list are all ingredients of TCM formulae that appear in the modern and/or classical lists. This means that the shared species in the five collections reflect the common species used in both historical TCM formulae and modern Chinese patent medicine. When we exclude the Sloane collection, all 47 shared species appeared in the formulae in the two lists. The high degree of consistency indicates that the shared species as ingredients for the traditional formulae have been used with high frequency in the past and present.

What is worth mentioning is that the flowers of *Lonicera japonica* Thunb. (Lonicerae Japonicae Flos, 金银花 jīn yín huā), appearing in all four collections and the modern trade list, are used as a major ingredient of TCM formulae in both the classical and the modern lists. *Lonicera* flowers are included in more than 420 TCM formulae, and have always been a frequently used medicine throughout Chinese history.[18,19] In 2020, Lianhua Qingwen granules, which contain *Lonicera* flowers, were widely used in the treatment of Covid-19 in China.[34] This vivid example of continuity in CMM from ancient times to today was also shown in the physical specimens in the historic collections.

Currently, the European Union has demanded analytical and pharmaco-toxicological tests and clinical trials since the Directive 65/65/EEC in 1965 and the amended directive 2001/83/EC before Chinese herbal products can be legally registered as medicines in EU member states.[35] A systematic regulatory framework was established after the enforcement of the traditional herbal medicinal products directive (Directive 2004/24/EC), which registered herbal products with long-standing use in a simplified way, with respect to the proof of efficacy and data on safety. In the directive 2004/24/EC, any non-European herbal medicinal product is required to have at least 30 years of traditional use evidence, and evidence of 15 years of traditional use in the EU.[36] Our current research provides new information on the traditional use of multiple species and plant parts over time, as we know that the herbal materials analyzed in this study can be traced back to China (Sloane and Catlender collections, Zhong Hua trade list) or Chinese pharmacies in the Malay peninsula (Hooper collection) or Indonesia (Westhoff collection).

4. Conclusion

In the four historical collections of CMM included in our analysis, we can witness great continuity but also subtle changes in traditional Chinese medicine in a time span of 300 years. In general, the proportion of plant families and medicinal plant parts remain similar. Fabaceae and Asteraceae were the most represented plant families but did not dominate the floristic diversity. A total of 14 species were present in all studied collections, and 47 were shared by all but the oldest (and least complete) Sloane collection. Still, several new medicinal parts appeared in younger collections, while some toxic CMM (Aristolochiaceae products) and endangered animals disappeared from the most recent collection and the modern trade list due to the safety issues. These four historical CMM collections have been personal showcase collections and preserved in museums or scientific institutions in Europe. These materials have not been used as medicines in Europe, however they may have indirectly influenced the European view of herbal medicine. In addition, changes of CMM in these historical collections, particularly the Westhoff and Hooper collections, which originate from outside of China, may have been influenced by local medicinal practices or the availability of certain plant resources. To prove this hypothesis, further investigation is needed on regional variation in TCM. Identification problems hindered a full comparison among all specimens in the collection. Our investigation contributes to a better understanding of time dependent changes in CMM use, either caused by safety concerns, conservation issues or innovation in traditional Chinese medicine.

Declaration of competing interest

The authors declare that they have no conflicts of interest relevant to the publication of this document.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtcme.2021.11.001.

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