Scientific Research Publishing

Open Journal of Social Sciences, 2024, 12, 165-185
https://www.scirp.org/journal/jss
ISSN Online: 2327-5960
ISSN Print: 2327-5952

Tea in Traditional Chinese Medicine and the Research Trend of Tea Medicine: A Quantitative Study

Jianan Wang[1,2], Runhe Zhang[3*]

[1]Department of History of Science and Scientific Archeology, University of Science and Technology of China, Hefei, China
[2]Department of History, Purdue University, West Lafayette, USA
[3]Shanghai YK Pao School, Shanghai, China
Email: *s18338@ykpaoschool.cn

How to cite this paper: Wang, J. N., & Zhang, R. H. (2024). Tea in Traditional Chinese Medicine and the Research Trend of Tea Medicine: A Quantitative Study. *Open Journal of Social Sciences*, *12*, 165-185.
https://doi.org/10.4236/jss.2024.1211012

Received: November 30, 2023
Accepted: November 12, 2024
Published: November 15, 2024

Abstract

Tea, with its dual attributes of being both drinking and medicinal, has been favored by people since ancient times. This article aims to illustrate the transition of tea into a medicinal substance by delineating the historical progression of medicinal tea, differentiating it from alternative medicinal teas, analyzing prevalent forms of medicinal tea, and examining the research trend of globalizing tea-based medicine through bibliometric research methods. Furthermore, it explores several factors hindering the ongoing development of medicinal tea in China.

Keywords

Tea, Traditional Chinese Medicine, Tea Medicine, Bibliometric

1. Introduction

Tea, derived from the leaves and buds of *Camellia sinensis* (L.) O. Kuntze of the Camelliaceae family, is one of the most popular drinks due to its pleasant taste and perceived health effects. In a narrow context, tea specifically denotes beverages crafted from tea leaves, a definition that has later broadened to encompass all herbal infusions made from various plant parts such as flowers, leaves, seeds, and roots. Examples include chrysanthemum tea, fruit tea, and herbal tea (Zhang & Xiao, 2019; Zhou, 1993). For clarity, this paper concentrates on the medicinal applications of tea sourced from the leaves of *Camellia sinensis* plants within the Camelliaceae family.

The health benefits associated with tea consumption are likely due to the high

levels of bioactive compounds, particularly flavonols, polyphenols and polysaccharide (Benzie & Wachtel-Galor, 2011). Tea and Traditional Chinese Medicine (TCM) share a deeply intertwined relationship. Medicinal tea within TCM prescriptions represents a pharmaceutical form of treatment that blends tea with various herbs and botanicals to address ailments. For the purpose of simplicity, this article adopts the term "medicinal tea" to encompass all TCM formulations incorporating tea ingredients (Cai et al., 2020).

The classification of tea solely as a beverage or a medicine is not straightforward, because tea and medicine are intricately intertwined. Despite being primarily consumed as a beverage, tea has consistently retained its medicinal significance and value throughout history. The earliest instances of medicinal tea date back approximately 1800 years to the Three Kingdoms period, as documented by Zhang Biao in *Guan Ya*. This era witnessed the usage of sober medicinal tea, highlighting tea's dual role as both a beverage and a form of medicinal therapy in China (Tao, 2016).

Theoretical concepts and practices within Chinese medicine during its formative years played a pivotal role in shaping the evolution of medicinal tea. The Tang and Song dynasties marked a golden era for the advancement of medicinal tea. The term "medicinal tea" was formally introduced in canonical texts, notably Wang Huaiyin's *Taiping Sheng Hui Fang* during the Song Dynasty (Wu & Yan, 2017). However, starting from the Yuan and Ming dynasties, Traditional Chinese Medicine (TCM) practitioners encountered assertions such as "tea is bitter and cold, detrimental to the spleen, stomach, and kidneys" when utilizing tea as a medicinal agent. Over time, medicinal tea transitioned from the traditional approach of pure tea or tea-based formulations to compositions where Chinese herbs took precedence, with tea serving as a supplementary component or being altogether excluded (Jiang et al., 2019).

This paper meticulously traces the historical evolution of medicinal tea, commencing from the Three Kingdoms era and extending to contemporary times. It discerns the distinctions between medicinal tea and alternative tea-based beverages, dissecting typical instances and synthesizing insights gleaned from previous medical practices. Additionally, it probes into several impediments obstructing the advancement of medicinal tea. Furthermore, leveraging bibliometric research outcomes concerning the trends in tea medicine research within China and globally, this study offers pertinent recommendations aimed at surmounting multifaceted obstacles hindering the integration of tea into medicinal practices and the subsequent development of tea-based medicine.

2. A Brief Global History of Tea

Tea transcends its conventional role as a mere beverage or culinary ingredient. It holds therapeutic properties that contribute to disease treatment and healthcare. Notably, historical texts document the medicinal virtues of tea. The second emperor of China, Shen Nung, is believed to have discovered tea when a leaf from

the *Camellia sinensis* plant blew into his cup of hot water in 2737 BCE. During the Eastern Han Dynasty, renowned physician Hua Tuo recorded in the *Food Theory* (Shi Lun) that "Long-term consumption of bitter tea helps to improve cognitive abilities" ("Ku Cha Jiu Shi, Yi Si Yi"). Similarly, in the Tang Dynasty, Sun Simiao noted in *A Thousand Gold Pieces Prescriptions* (Qian Jin Fang) that "Tea can alleviate severe headaches" (Cha Neng Zhi Tou Tong Ru Po). Furthermore, Chen Zangqi's Supplement to Materia Medica highlighted tea's capacity to dissipate heat and miasma, benefiting the gastrointestinal tract (Cha Po Re Qi, Chu Zhang Qi, Li Da Xiao Chang). Li Shizhen, a prominent figure in the Ming Dynasty, affirmed in his seminal work Compendium of Materia Medica (Ben Cao Gang Mu) that "Tea, with its bitter and cooling properties, possesses the ability to pacify internal heat" (Cha Ku Er Han, Yin Zhong Zhi Yin, Chen Ye, Jiang Ye, Zui Neng Jiang Huo). These historical references underscore the integral connection between tea and the realm of medicine, affirming its enduring status within the domain of therapeutic substances.

Tea also has a long history outside China. The first European to encounter and write about tea was the Portuguese Jesuit missionary Father Jasper de Cruz in 1560. Around 1650, the Dutch introduced various teas and tea traditions to New Amsterdam (later New York) in the U.S. The first tea sold as a health beverage was available at Garway's Coffee House in London, England in 1657. In 1826, John Horniman introduced the first retail tea in sealed, lead-lined packages. In 1870, Twinings of England began blending tea for uniformity. During a heatwave at the St. Louis World Fair in 1904, the Englishman Richard Blechynden created iced tea. In 1908, New York tea importer Thomas Sullivan inadvertently invented tea bags when he sent tea to clients in small silk bags, which they mistakenly steeped whole. Finally, the world's first instant tea was introduced in 1953. Nowadays, black tea is consumed principally in Europe, North America, and North Africa, whereas green tea is popular throughout Asia (Benzie & Wachtel-Galor, 2011).

3. The Medical Value of Tea

With advancements in science and technology, contemporary researchers have identified the active ingredients present in tea. Tea comprises alkaloids, including caffeine, theophylline, and theobromine, which can stimulate the central nervous system, providing a refreshing effect to the brain, alleviating fatigue, and exerting cholesterol-lowering and anti-atherosclerotic effects (Tan et al., 2017). Tea polyphenols encompass a group of polyhydroxy phenolic compounds found in tea, with main constituents such as flavanols, anthocyanins, and phenolic acids. These compounds have been found to enhance capillaries, improve microvascular wall permeability, and possess antibacterial and anti-inflammatory properties. Meanwhile, some specific polyphenols contained in the tea can be essential in delaying the onset or halting the progression of Parkinson's Disease (Caruana & Vassallo, 2015). Additionally, polysaccharides like tea polysaccharides, dietary fiber, and pectin, which contribute to health benefits such as hypoglycemic effects,

antioxidant properties, and promotion of intestinal metabolism. These components collectively contribute to the overall health-promoting properties of tea (Nantz et al., 2009).

Catechins, a series active medical ingredients of the green tea are with neuroprotective activities (Benzie & Wachtel-Galor, 2011), especially the polyphenols, flavan-3-ols, epicatechin and its gallate derivatives. These compounds are also found in lower concentrations in black tea, where they are oxidized to form theaflavins and thearubigins (Finger et al., 1992; Balentine et al., 1997). The principal flavonols in tea are conjugates of quercetin and kaempferol, with myricetin present in lower quantities. The conjugates can range from mono- to di- and triglycosides (Wang & Sporns, 2000; Del Rio et al., 2004). Additionally, tea contains other related compounds such as gallic acid, quinic esters of gallic, coumaric, and caffeic acids, as well as the purine alkaloids theobromine and caffeine. Proanthocyanidins and trace amounts of flavones are also present (Crozier et al., 2009).

In addition to tea from the Camelliaceae family, the medicinal properties of chamomile tea, one of the oldest documented medicinal plants, are also considered in recent literature (Khan et al., 2014). Chamomile has been recognized since ancient times for its anti-inflammatory, astringent, and antioxidant properties, particularly in its floral parts (Srivastava et al., 2010). Evidence from the current study indicates that chamomile tea has glucose-lowering effects in alloxan-induced diabetic rats, with effects comparable to those of glibenclamide. Consequently, daily consumption of chamomile tea may be a potentially useful alternative for managing hyperglycemia and could serve as a substitute for conventional medical treatments (Bayliak et al., 2021).

4. The History of Tea Medicine in China

4.1. Before Tang Dynasty

The term "tea medicine" does not appear in medical literature before the Tang Dynasty, although the underlying concept existed. In the Guang Ya of the Three Kingdoms period, Zhang Biao recorded the preparation of tea leaves into cakes or fine powder, which were brewed with boiling water and infused with ingredients like scallion, ginger, and orange to create a refreshing tea medicine. During the Five Dynasties and Ten Kingdoms period, Tao Hongjing of the Liang Dynasty noted the potential weight-loss benefits of bitter tea (Ku Cha Neng Qing Shen Huan Gu) and suggested that substances such as asparagus could also be utilized as tea (Lan et al., 2020; Xi, 2017).

In the Tea Classics (*Cha Jing*), the tea sage Lu Yu criticized the practice of mixing various ingredients with tea, stating, "(Tea) Or with scallions, ginger, Chinese dates, orange peel, cornelian, mint, etc., boiled for boiling, or made it slippery, or cooked to defoam, tastes like waste water in the ditch, but such custom has not been stopped yet" (Huo Yong Cong Jiang Zao Ju Pi Zhu Yu Bo He Zhi Deng Zhu Zhi Bai Fei Huo Yang Ling Hua Huo Zhu Qu Mo Si Gou Qu Jian Qi Shui Er Er Xi Su Bu Yi). He believed that this concoction, resembling ditch water due to its

mixture of ingredients and herbs, persisted from before the Tang Dynasty and served as the prototype of tea medicine, laying the foundation for its development (Jiang et al., 2019).

4.2. Tang Dynasty

During the Tang Dynasty, tea culture flourished, providing a conducive environment for the development of tea medicine. Although the term "tea medicine" did not appear during this period, it is likely because tea was considered a part of Chinese medicine, and doctors did not specifically emphasize its "tea" properties. In the Tang and Song dynasties, tea was primarily consumed in the form of spherical or cake-shaped tea. Drinkers would typically crush the spherical or cake-shaped tea into powder and consume it using either the "decoction method" (Jian Cha Fa) or the "point method" (Dian Cha Fa), which were the mainstream customs of tea consumption. The former involved pouring boiling water over the tea powder, while the latter involved rinsing the tea paste with boiling water in the cup. Tea was predominantly used as medicine in the form of tea powder, a practice influenced by the tea processing methods and drinking customs of the time.

The earliest medicine tea single recipes were recorded in Sun Simiao's *Wings of the Thousand Gold Pieces Formulary* (Qian Jin Yi Fang) volume 22 in the Tang Dynasty: "the treatment of dysentery formula: boiled really good tea lightly, serving two or three liter or one or two servings to mild symptoms" (Zhi Shi Li Fang Dan Zhu Zhen Hao Cha Ye Fu Er San Sheng Qing Zhe Yi Er Fu). Tang dynasty medical scientist Chen Zangqi also had the famous assertion"tea is the medicine of all diseases" (Cha Wei Wan Bing Zhi Yao). Accordingly, although people did not grasp modern technology then, they recognized the medicinal value of tea from a large number of experience in the struggle with disease, and made use of tea for the treatment of diseases, such as dysentery.

The Tang Dynasty also had a record of tea made into medicinal pills. Guo Jizhong in Tang Dynasty recorded "scallion juice gnat tea pill" (Cong Xian Na Cha Wan) in the *Formula for Women* (Fu Ren Fang): "(women) constipation after childbirth, to pound scallion for juice, mix it with gnat tea powder and get the pill, take it for curing the constipation" (Fu Ren Chan Hou Bian Mi Yi Cong Bai Dao Zhi Tiao Na Cha Mo Wei Wan Fu Zhi Zi Tong). This episode shows that the tea medicine in the form of pill began to appear in the Tang Dynasty. There was also a white plum gnat tea pill could astringe dysentery, and the formula of which was pounding appropriate amount gnat tea powder and white plum for the pill. Both of the above pills used gnat tea, which was a kind of green tea processed in gnat shape (Lan et al., 2020).

And tea substitute is also initially introduced in the Tang Dynasty, refers to the selection of one or two or several herbs (often developed into coarse powder) decocted or brewed by boiling water. Tea substitute is different from tea medicine, generally composed of pure Chinese medicine, and does not contain tea ingredients (Tao, 2016). Wang Tao of the Tang Dynasty, the Secret of Wai Tai (Wai Tai

Mi Yao) included "new formula of tea substitute", containing Astragalus, Medulla Tetrapanacis, Poria and other Chinese herbs, and no tea ingredients. Although it appeared before the term "tea medicine", it formally introduced the concept of "tea substitute" (Zhu, 2018).

4.3. Song Dynasty

The term "tea medicine" formally appeared in the chapter of "tea medicine prescriptions" in Volume 96 and 97 of Wang Huaiyin's *Peaceful Holy Benevolent Prescriptions* (Tai Ping Sheng Hui Fang) in the early Northern Song Dynasty, in which eight tea medicine prescriptions were included, among which "sulfur tea prescription" and "gypsum tea prescription" were the most representative. In the late Northern Song Dynasty, there was also a record of "gypsum tea" in Liu Wansu's *Clear Synopsis on Recipes* (Xuan Ming Fang Lun), and the main formula of which was calcined gypsum, ligusticum wallichii, fried licorice, scallion and tea. It was mainly used to treat headache, eyes inflammation and pain caused by stomach heat. However, these prescriptions contain mineral drugs, such as sulfur and gypsum, which have certain health risks (Lan et al., 2020; Xi, 2017).

4.4. Yuan Dynasty and Later

Since the Yuan Dynasty, the broad sense of tea medicine has been transitioned from the traditional way of simple tea or tea-based, tea and medicine together to medicinal food and tea substitute, and tea blended tea medicine formulas began to be independent from the traditional Chinese medical formulas in the form of dietary therapy (Lan et al., 2020). Imperial physician Khu Si Hui wrote about diet therapy, Principles of Correct Diet (Yin Shan Zheng Yao) recorded the preparation of a kind of Chinese wolfberry tea, with nourishing essence, warmth and tonicity, and helping with weight loss. Imperial Medicine Formulas (Yu Yao Yuan Fang) written by Xu Guozhen in Yuan dynasty collected of nearly a thousand formulas but no tea medicine prescriptions included.

It can be seen that tea medicine at this time has been clearly classified as "food treatment", more towards the function of health care. In the Ming Dynasty, Zhu Su, fifth son of Zhu Yuanzhang, compiled the Prescriptions for Universal Relief (Pu Ji Fang), which included 61,739 prescriptions before the Ming Dynasty and about 1,500 tea medicine prescriptions and tea drinks among which. At the "food treatment - tea medicine" chapter of the book included the tea medicine prescriptions from Peaceful Holy Benevolent Prescriptions (Tai Ping Sheng Hui Fang). With the passage of time, the status of tea medicine in health care was gradually declining (Jiang et al., 2019). In the middle of the Ming Dynasty, Li Shizhen had a detailed discussion in his Compendium of Materia Medica (Ben Cao Gang Mu) that "tea is bitter and cold, hurting the spleen, stomach and kidneys" (Cha Xing Ku Han Shang Pi Wei Shen Zang). In the original medical archives of the Qing dynasty, the imperial doctors of the imperial hospital preferred tea substitute than tea in order to prevent and cure diseases. The medical book Selected Medical

Prescriptions for Emperor Guangxu and Empress Dowager Cixi with Comments (Ci Xi Guang Xu Yi Fang Xuan Yi) recorded that Cixi had drinking clearing heat and relieving cough tea substitute (Qing Re Zhi Ke Dai Cha Yin) as well as other tea substitutes such as producing saliva tea substitute (Sheng Jin Dai Cha Yin).

5. The Modern Challenge of the Tea Medicine

By searching ancient and modern medical texts and literature, and discussing them in relation to specific diseases, the reasons that hindered the development of the medicinal use of tea, and the problems that tea medicinal use may have faced are roughly as follows.

5.1. Tea Is Bitter and Cold

According to the viewpoint of TCM, tea has the effect of nourishing Yin and generating saliva, which can quench thirst, treat dysentery and obesity. Since the Song Dynasty, many famous Chinese doctors talked about the hazards of drinking teain their writings, especially Li Shizhen as the most.

Li Shizhen's *Compendium of Materia Medica* (Ben Cao Gang Mu) has pointed out that tea is harmful to people with cold and weak blood as well as women (because most women have cold bodies). At the same time, he also pointed out that tea has addictive, long-term addiction to tea is harmful to human health: "people who have been addicted to tea, chewing for long time and hurting the essence, blood is not healthy as well, seems weak and ill, but still without regret, which is really lamented" (Ren You Shi Cha Cheng Pi Zhe, Shi Shi Ju Chuo Bu Zhi Jiu Er Shang Ying Shang Jing Xue Bu Hua Se Huang Cui Wei Ruo Bao Bing Bu Hui You Ke Tan Wan). Even he combined with the lessons of their own tea, giving the evaluation of "attribute benefit to the tea power, while ignore the disaster caused by tea. Easy to know the near fortune, but hard to see the far disaster" (Huo Yi Ze Gui Gong Cha Li Yi Huan Ze Bu Wei Cha Zai Qi Fei Fu Jin Yi Zhi Huo Yuan Nan Jian Hu) (Xi et al., 2016; Xi et al., 2017). Views such as "thirst and drinking tea after drinking alcohol will bring cold into the kidney meridian. People with cold pain in the waist, feet and bladder, and suffer from edema contracture paralysis diseases" (Da Ke Ji Jiu Hou Yin Cha Han Ru Shen Jing Ling Ren Yao Jiao Pang Guang Leng Tong Jian Huan Shui Zhong Luan Bi Zhu Ji) and other or similar views also found in the *Diet Instructions* (Yin Shi Xu Zhi) and other medical works (Xiao et al., 2018).

According to traditional Chinese medicine, young people have strong blood function and healthy spleen and stomach, so appropriate tea can fall the fire and benefit the body. But long-term tea drinking will bring risks, even if the body is no longer as healthy as young, the habit of drinking tea is difficult to change. The addiction to tea will make people mentally exhausted, hurt their spleen, stomach and kidneys. In view of this, the subsequent medical practitioners preferred to develop a tea drink composed mainly of pure Chinese medicine, which is more suitable for long-term use than tea medicine formulas, such as the aforementioned

Qing Dynasty imperial doctors preferred tea substitute than tea medicine (Jiang et al., 2019; Lan et al., 2020).

From all above, we can conclude that some of the theoretical ideas of early Chinese medicine and other tea drinking practices like "point tea method" (Dian Cha Fa) or "decoction tea method" (Jian Cha Fa) did promote the development of tea medicine, but tea "bitter cold nature, hurt the spleen, stomach and kidneys "and other assertions do constitute a great obstacle to the development of tea medicine, which needs to be justified by contemporary medical theory (Xi et al., 2017).

5.2. The Influence of Traditional Concepts Such as "Tea Dissolving Efficacy"

The origin of tea is often associated with the "Shennong got tea for detoxification" allusion, and then there were doctors got conclusions like "tea could detoxification", and "could not drink tea during medication". Tea and traditional Chinese medicine also have the function of reducing the toxic side effects of drugs. Relevant records were first seen in *General Records of Holy Universal Relief* (Sheng Ji Zong Lu) in the Song Dynasty, *Diet Instructions* (Yin Shi Xu Zhi) in the Yuan Dynasty, and Ge Zhi Jing Yuan in the Qing Dynasty. These questionable assertions and "tea is bitter cold, hurt the spleen, stomach and kidneys" and other similar assertions, so that later generations of doctors on the role of tea have certain misunderstandings, both afraid of tea to solve the medicinal effects of other Chinese medicines with its combination, but also afraid of tea is bitter cold, if taken for a long time in the form of health formulas, may hurt the spleen, stomach and kidneys (Xi, 2017; Xi et al., 2017).

In addition to the "tea dissolving efficacy", there are also "tea dissolving poison", the mechanism seems to be related to the physical, chemical and medicinal effects of tea. The "miscellaneous treatment - Chinese medicine poison" chapter of *General Records of Holy Universal Relief* (Sheng Ji Zong Lu) recorded a "detoxification pill formula" (Jie Du Wan Fang) mainly for "Chinese medicine poison, unbearable heart and abdominal pain" (Zhong Yao Du Xin Fu Qie Tong Bu Ke Dang). Also, there was a guidance of "to unknown poison, drink a large cup of clear and warm tea" (Bu Zhi Suo Zhong Du Wu Ji Yi Cha Qing Yi Da Zhan Fang Wen Yan Xia), indicating that the "detoxification pills" with clear tea delivery, through diuretic, diarrhea and other mechanisms to reduce the absorption of toxic substances in other TCM prescriptions. Zhang Yuansu in the Jin Dynasty mentioned the use of bitter tea when discussing the method of gushing and vomiting in spleen diseases, while Li Shizhen also believed that tea decoction had an emetic effect, saying "decoction of strong, vomiting wind-heat phlegm and saliva" (Nong Jian Tu Feng Re Tan Xian) (Jiang et al., 2019). The possible principle of it is to use higher concentrations of bitter substances in tea (tea polyphenols, ester-type catechins, etc.) to induce vomiting in order to reduce the absorption of toxic substances in the human body (Xi et al., 2017).

The opinions of "tea dissolving efficacy" and "tea dissolving poison" often go

hand in hand, and either of them are objective. The reason for this, in addition to the brewing of tea water itself has a diuretic effect, "tea dissolving efficacy" and "tea dissolving poison" is also closely related to the chemical substances contained in tea leaves. To study these issues, contemporary scholars currently mainly divided them into cellulose said and tea polyphenols said (Xi et al., 2016).

Tea has a high content of cellulose. Cellulose is a kind of dietary fiber that cannot be digested and absorbed by the body, and is also a nutrient necessary for the human digestive process. According to the experimental data provided by Wang Shufang et al., the cellulose content in tea leaves ranged from 11.1% to 38.8%, with an average of about 15%. Brick tea is more coarse and old, and contains more tea stems, in which the cellulose content is even as high as 32.1% - 38.8%. The cellulose in tea can promote intestinal peristalsis, reduce the residence time of gastrointestinal contents in the gut, and at the same time promote defecation and metabolism of toxic substances out of the body. Due to the mainstream tea drinking methods "point tea method" (Dian Cha Fa) and "decoction tea method" (Jian Cha Fa) in Tang and Song dynasties, tea cake were often powdered, decocted and eaten together with tea residue, so "cellulose said" confirmed the statement that drinking and eating tea both benefit urinating and digesting, and then confirmed the theory of dissolving poison. What's more, since cellulose at room temperature is neither soluble in water, nor soluble in general organic solvents, tea in the form of tea broth into the medicine of tea medicine can exclude such effects (Wang & Lai, 1995).

Some scholars believe that the tea polyphenols contained in tea will react with proteins, alkaloids or metal elements in drugs to produce insoluble compounds, which will affect the absorption of the active ingredients of drugs and reduce the efficacy. Xi et al. suggested that tea polyphenols in tea have the property of complexing and precipitating metal ions, thus suggesting that tea consumption has the potential to inhibit iron absorption. This conclusion was partially confirmed by RF Hurrell et al. RF Hurrell et al. found experimentally that black tea consumption decreased iron absorption by 79% - 94%. In contrast, the study by L Mennen et al. showed no correlation between the iron nutritional status of humans and the type, amount and duration of tea consumption, and the study by Greqer JL et al. also showed that tea had a weak effect on iron content or iron absorption in rat tissues (Xi et al., 2016; Zhang & Xiao, 2019).

Although tea polyphenols are high in tea leaves (about 18% - 36%), they are chemically unstable and susceptible to other chemicals. Shen et al. found that ethanol and ascorbic acid (vitamin C) can slow down the oxidation of tea polyphenols, so it is reasonable to assume that certain compounds, bacteria or enzymes in the human body contribute to the retention of tea polyphenols in the body, thus prolonging the metabolic process of tea polyphenols in the human body (Shen et al., 2019). In addition, different teas contain different levels of tea polyphenols. Therefore, the question of whether tea polyphenols ingested by drinking tea affect the absorption of iron and other metal elements, alkaloids and proteins, as well as

the pharmacokinetics of tea polyphenols and other substances, remains to be studied in depth.

5.3. Misrepresentation of Pathology and Pharmacology

Some ancient medical texts are unclear about the pathology of diseases and the pharmacology of tea, even with some superstitious and legendary elements. These inaccurate information on contemporary scholars to study the tea into the problem of medicine caused trouble. The "earwig urinary sore" is a typical example, first seen in *General Treatise on the Causes and Symptoms of Diseases* (Zhu Bing Yuan Hou Lun) in the Sui Dynasty and *General Records of Holy Universal Relief* (Sheng Ji Zong Lu) in the Song Dynasty. According to the definition in the book, "earwig urine sores" were sores caused by the urine of earwig insects shooting onto the human skin, causing skin rashes and severe pain. The tea powder compressed for this disease was grated grass tea or wax tea and applied with raw oil (Zhang & Xiao, 2019).

Combining the description in *General Treatise on the Causes and Symptoms of Diseases* (Zhu Bing Yuan Hou Lun) and contemporary medical theory, the so-called "earworm urine sore" is actually "herpes zoster". This is a disease caused by Varicella-Zoster Virus (VZV). In ancient times, medical doctors did not know enough about the pathology and classified it as "caused by earwig urination", which does not make sense. If the herpes zoster is treated by applying a mixture of tea powder and oil as described in the *General Records of Holy Universal Relief* (Sheng Ji Zong Lu), it is likely that the disease will be misunderstood and even worsen, leading to a series of complications. Even with the current Chinese medicine approach to treating herpes zoster, combined formulas are mostly used to remove the VZV virus from the body and relieve the after-effects of nerve pain, which can never be achieved by just using tea.

5.4. Efficacy Issue

In some of today's tea medicine research efforts, there are still some problems with regard to efficacy indicators. Here, still taking herpes zoster as an example, the commonly used drugs in Western medicine for herpes zoster are acyclovir, famciclovir, alpha-interferon, glucocorticoids, etc. There are also more formulas in Chinese medicine for herpes zoster, which contain tea medicine formulas, such as a combined formula consisting of Longdan Xiegan Decoction and Chuanxiong Chatiao Powder. Jiang used the oral Chinese medicine such combined formula as the experimental group and the control group was panaciclovir therapy, which was judged according to the Diagnostic Efficacy Criteria for Chinese Medical Evidence, and found that the experimental group had better efficacy on the disease and claimed a confidence level of $p < 0.05$, meaning that it was statistically significant (Jiang, 2010). In contrast, Leng did not set efficacy criteria when discussing the treatment of herpes zoster with Longdan Xiegan Decoction and Chuanxiong Chatiao Powder, but only used subjective judgments such as "according to the

clinical observation" and "generally 3 - 5 doses can cure the disease and no neuralgia remains". This is a small amount of description to prove its efficacy, which discredits the credibility (Leng, 2005).

The criteria for evaluating the efficacy of herpes zoster treatment in the Diagnostic Efficacy Criteria for Chinese Medicine Evidence covered in Jiang's clinical experiment are shown below: (1) Cured: lesions regressed, clinical signs disappeared, and no pain sequelae; (2) Improved: rash regressed by about 30% and pain significantly reduced; (3) Ineffective: rash regressed by less than 30% and pain still present (Jiang, 2010). This criterion has some problems, mainly because patients are susceptible to interference by various factors when evaluating pain perception, such as psychological suggestion, nervous tension and differences in pain tolerance, which affects its accuracy and objectivity. The criterion uses the rash condition and pain sensation as the efficacy criteria, ignoring factors such as viral infection, which is not objective and comprehensive enough. Therefore, based on such efficacy criteria and clinical trials, the conclusion that "the efficacy of herbal tea for herpes zoster is significantly better than that of panaciclovir" is not convincing.

In contrast, the efficacy criteria developed in some Western or combined Western and Chinese medicine efforts for herpes zoster are significantly more accurate and objective, taking into full consideration psychological factors and other circumstances while referring to laboratory indicators such as serum inflammatory factors and cytokines. Ye et al. combined subjective efficacy criteria with objective efficacy criteria, mainly consisting of overall clinical efficacy, VAS pain scores, anxiety self-assessment scale (SAS) scores, and Th1/Th2 cytokine and serum inflammatory factor levels, which were more accurate and objective compared with the efficacy criteria of the Diagnostic Efficacy Criteria for Chinese Medicine Evidence on herpes zoster (Ye et al., 2020). In addition, in his study of Daqing Lianqiao Soup combined with Wananlovir hydrochloride tablets for the treatment of herpes zoster, Zhang also designed a more complete set of efficacy criteria, which included clinical efficacy, blister stopping time, time to crusting, time to debridement, serum interleukin IL-2, IL-6, and IL-10 levels before and after treatment, and the occurrence of adverse reactions during treatment in the assessment of efficacy criteria indicators (Zhang, 2020).

If the clinical efficacy of tea medicine is significant, supported by the objective quantitative indicators of Western medicine, and clinical experiments with statistical significance, then whether "tea is bitter and cold" or "tea dissolving efficacy", or even the ancient medical texts of various inaccuracies and fallacies, cannot stop the trend of tea into medicine. The efficacy standard of tea medicine should follow the principle of "emphasis on clinical efficacy" in Chinese medicine while adding objective quantitative indexes from Western medicine, so as to balance comprehensiveness, accuracy and objectivity, which can not only strongly promote the development of contemporary tea medicine, but also provide accurate reference for other tea medicine researchers (He et al., 2020).

6. The Research Trend of Tea Medicine in China and the World

In the previous parts, we discussed the tradition of China's tea medicine research over the long period of time and pointed out the several problems of current tea medicine research issues in China. To further evaluate the research trend of tea medicine in China and the world, bibliometric data from the authoritative database can be used (Yi & Xi, 2008). Since tea medicine originated in China, we hypothesize that China dominates the world in tea medicine research with significant impact on related area.

The emergence of bibliometric analysis has broken through the limitations and shortcomings of the traditional quantitative research based on historical statistics and even the historical material analysis, and has greatly promoted quantitative research towards systematization and systematization, and has also directly prompted scientometrics to ascend to the historical stage as an independent discipline. The bibliometric study is useful to evaluate certain academic fields from both quantitative and qualitative approaches as well as the competency of research efforts accomplished in these fields (Aria & Cuccurullo, 2017) for indicating the popularity of the research field (Price, 1976). These data help scholars to figure out the progress concerning almost any topic by providing comprehensive assessments at various levels of aggregation (Zhao & Jiang, 1985).

We choose the Granger causality model to examine the linkage of tea medicine research in China and in the world in the recent 30 years (1993-2022). Granger causality, established by Granger in 1969 (Granger, 1969), is widely applied to ascertain the existence of predictive relationships between two time-series variables (Kónya, 2006). This technique can forecast a relationship between one set of time-series data and another one, especially in dealing with a macro, so it fits our research goal, that is, by the predictive relationship between the research trend of tea medicine in both China and the world based on time-series bibliometric data. Please note that such "Causality" does not mean true causation but measures the possibility of evaluating whether one variable predicts or forecasts the other and vice versa (Luan et al., 2022).

In the following parts, we examine the interaction among indicators of tea medicine in China and in the world by Granger Causality to reveal their one-way or two-way dynamic equilibrium relationship. We define the meaning of each variable in this part.

"*tmcnki*"—quantity of articles about tea medicine on CNKI database (one of China's most biggest academic databases);

"*tmwos*"—quantity of articles about tea medicine on Web of Science Core Collection database;

"*tmwoscn*"—quantity of articles about tea medicine on Web of Science Core Collection database published by Chinese author (counted as first communication address);

"*tmwoscnp*"—percentage of articles about tea medicine on Web of Science

Core Collection database published by Chinese author (counted as first communication address). To be specific, "*tmwoscnp*" is calculated as Equation (1):

$$tmwoscnp_{year} = \frac{tmwoscn_{year}}{tmwos_{year}} \times 100\% \quad (1)$$

"*lntmcnki*"—the logarithmic form of natural base of quantity of articles about tea medicine on CNKI database (one of China's biggest academic databases);

"*lntmwos*"—the logarithmic form of natural base of quantity of articles about tea medicine on Web of Science Core Collection database;

"*lntmwoscn*"—the logarithmic form of natural base of quantity of articles about tea medicine on Web of Science Core Collection database published by Chinese author (counted as first communication address);

"*lntmwoscnp*"—the logarithmic form of natural base of percentage of articles about tea medicine on Web of Science Core Collection database published by Chinese author (counted as first communication address).

We built our bibliometric datasets based on the "CNKI" database and "Web of Science Core Collection" database. The search strategy is as follows:

(1) Search the keyword "tea medicine" in the CNKI database during 1993-2022 for variable *tmcnki*.

(2) Search the keyword "tea medicine" in the Web of Science Core Collection database during 1993-2022 for variable *tmwos*.

(3) Count the number of Chinese papers (counted as first communication address) appearing in *tmwos*, denoted as *tmwoscn*.

Table 1 demonstrates the descriptive statistics of all the variables mentioned above. Table 2 defines the variation of each group.

Table 1. Descriptive statistics of all the variables.

	tmcnki	*tmwos*	*tmwoscn*	*tmwoscnp*	*lntmcnki*	*lntmwos*	*lntmwoscn*	*lntmwoscnp*
Mean	52.400	388.767	69.300	0.124	3.830	5.720	3.347	−2.373
Median	48.500	313.000	29.000	0.0941	3.879	5.743	3.362	−2.364
Maximum	112.000	896.000	302.000	0.337	4.718	6.798	5.710	1.086
Minimum	13.000	74.000	1.000	0.0135	2.565	4.304	0.000	−4.304
Std.Dev.	26.169	259.266	81.355	0.0866	0.538	0.737	1.556	0.850
Skewness	0.757	0.595	1.316	0.688	−0.452	−0.115	−0.303	−0.613
Kurtosis	3.071	2.105	3.805	2.467	2.862	1.728	2.110	2.728
Jarque-Bera	2.873	2.770	9.475	2.725	1.044	2.089	1.449	1.972
Probability	0.238	0.250	0.009	0.256	0.593	0.352	0.485	0.373
Time Period	1993-2022							

Table 2. Variable definition of each group.

Group	Time Period	Dependent Variable	Independent Variable
1	1993-2022	*lntmwos*	*lntmcnki*
2	1993-2022	*lntmwos*	*lntmwoscn*
3	1993-2022	*lntmwos*	*lntmwoscnp*
4	1993-2022	*lntmwoscn*	*lntmcnki*

6.1. Unit Root Test

The unit root tests are used as a first stage in the research to ensure that all variables are stationary in level, 1st difference or 2nd difference (Dickey & Fuller, 1979). Here, we use ADF (Augmented Dickey-Fuller) unit root test, KPSS (Kwiatkowski-Phillips-Schmidt-Shin) unit root test, and PP (Phillips-Perron) unit root test to examine the stationary of each time-series variable in each group and summarized the collective test results (Phillips & Perron, 1988). Usually, choosing a proper lag order P for each group is at the first stage of the unit root test (Dickey & Fuller, 1981). Schwert (1989) suggested the range of lag order P by taking the maximum lag order as:

$$P_{max} = \left[12 \times \sqrt[4]{\frac{T}{100}} \right]$$

Note: T is the sample size, [*] represents the integer part of *, then using the AIC criterion to select the best lag order. When T is 30 (30 observes for each time-series variable from 1993 to 2022), the $P_{\max}$ is 7. Furthermore, Akaike Information Criteria is used to determine the reasonable lag order in these time-series, respectively.

6.2. Co-Integration Test Results

The collective unit root test results in **Tables 2-5** show that the time-series variables are not stationary in the same difference level. Apart from that, other time-series involved in this study are all first-order integral series. Consequently, we adopt co-integration analysis to test the long-run equilibrium relationship between these time-series pairwise variables both passed the unit root test in I(1).

The Engle-Granger Co-integration test is used widely for Co-integration analysis (Luan et al., 2022). By generating the residual series, making ADF unit root tests and calculating Error Correction Model, the Co-integration relationship between the two time-series variables in each group can be properly tested (Engle & Granger, 1987). Firstly, we employ the OLS (Ordinary Least Square) to find the residue time-series for each group, marked as ε*, while "*" means varieties of subscript of the variable. Then, we examine the stationary of ε* by ADF test and report the best result among three types of ADF tests (Intercept, Trend+Intercept, None), and find that ε* is stationary with above 95% confidence level in I(0) in all these groups. **Table 6** shows the test results of residual series of Engle-Granger Co-integration.

Table 3. ADF unit root test results.

ADF Tests Variables	Level		1st Difference		2nd Difference	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Intercept	Trend and Intercept
lntmcnki	−1.415	−4.087**	-	-	-	-
lntmwos	−1.943	−0.788	−1.748	−2.513	−3.762***	−3.060
lntmwoscn	−1.190	−2.410	−6.573***	−3.506	-	-
lntmwoscnp	−0.137	−4.367**	-	-	-	-

**$p < 0.05$, ***$p < 0.01$, lag order auto selected by AIC.

Table 4. KPSS unit root test results.

KPSS Tests Variables	Level		1st Difference	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
lntmcnki	0.920***	0.160**	0.0763	0.0417
lntmwos	1.090	0.0801	-	-
lntmwoscn	1.100	0.0613	-	-
lntmwoscnp	1.070***	0.0562	0.0885	0.0545

**$p < 0.05$, ***$p < 0.01$, Maxlag = 2 chosen by Schwert criterion.

Table 5. PP unit root test results.

PP tests Variables	Level				1st Difference			
	Intercept		Trend and Intercept		Intercept		Trend and Intercept	
	Z(rho)	Z(t)	Z(rho)	Z(t)	Z(rho)	Z(t)	Z(rho)	Z(t)
lntmcnki	0.289	0.974	−6.295	−2.111	−40.014***	−10.008***	−39.365***	−10.547***
lntmwos	0.411	3.283	−1.391	−1.365	−17.184***	−4.022***	−21.558***	−5.073***
lntmwoscn	1.062	1.700	−2.622	−1.665	35.905***	−8.393***	−35.128***	−12.336***
lntmwoscnp	−1.603	−2.420	−5.603	−2.109	−38.587***	−10.620***	−38.046***	−12.778***

**$p < 0.05$, ***$p < 0.01$, and the bandwidth is automatically selected by Newey-West Lags = 2 for all the items.

Table 6. The test results of residual series of Engle-Granger Co-integration.

Group	Regression Equation	Residual Series	ADF Test	Stationary
1	$lntmwos = 1.117 lntmcnki + 1.444$	ε_1	−3.588**	√
2	$lntmwos = 0.463 lntmwoscn + 4.171$	ε_2	−4.570***	√
3	$lntmwos = 0.801 lntmwoscnp + 7.622$	ε_3	−2.014**	√
4	$lntmwoscn = 2.434 lntmcnki - 5.975$	ε_4	−3.756**	√

**$p < 0.05$, ***$p < 0.01$.

The Error Correction Model (ECM), also known as DHSY model, was initially founded by Davidson, Hendry, Srba and Yeo, in 1978 (Davidson et al., 1978). In this model, we obtain the ECM equation by employing OLS regression inclusive of the residual series ε as the dependent variables. The results in **Table 7** prove that all the pairwise time-series variables are Co-integrated.

Table 7. The ECM model of each group.

Group	Variable	Equation after ECM Correction
1	*lntmwos*, *lntmcnki*, ε_1	$lntmwos = 1.487 lntmcnki + 0.374\varepsilon_{1,t-1} + \varepsilon_t$
2	*lntmwos*, *lntmwoscn*, ε_2	$lntmwos = 1.499 lntmwoscn - 0.755\varepsilon_{2,t-1} + \varepsilon_t$
3	*lntmwos*, *lntmwoscnp*, ε_3	$lntmwos = -2.205 lntmwoscnp + 2.835\varepsilon_{3,t-1} + \varepsilon_t$
4	*lntmwoscn*, *lntmcnki*, ε_4	$lntmwoscn = 0.925 lntmcnki + 0.614\varepsilon_{4,t-1} + \varepsilon_t$

6.3. Granger Causality

To examine whether there is a predictive relationship between Chinese tea medicine research and world's tea medicine research, we apply the Granger Causality Test to determine whether one time series useful in forecasting the other to reveal the pattern of change of the research trend (Wang et al., 2017). The Granger Causality test is a statistical hypothesis test for determining whether one time series can forecast another. Since the question of "true causality" is deeply philosophical, and because of the post hoc ergo propter hoc fallacy of assuming that one thing preceding another can be used as a proof of causation, the Granger Causality test finds are only considered as "predictive causality". In the context of this study, it is still useful to evaluate the research trend of tea medicine in China and the world because of its "predictive causality" in discussing the change of the research trend. **Table 8** shows the results of the Granger Causality.

Please note that the Granger Causality test results are sensitive to lag periods selection, and different lag periods may result in different test results (Granger, 1980). Therefore, in this section, our Granger Causality Test is carried out for years of lag period year by year, to clarify the interaction relationship between dependent variable and independent variable. In order to exclude incidental factors from interfering as much as possible, we only consider Granger Causality effects that are at the significant level no more than 5%.

Table 8. The Granger Causality results.

x does not Granger cause y: Ch2 Statistics				y does not Granger cause x: Ch2 Statistics				Lag Length
Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4	
0.0407	0.00264	0.00264	1.124	6.719**	10.019***	12.547***	2.648	1
1.967	2.173	2.173	1.931	2.100	2.763	2.688	1.963	2
1.612	3.732**	4.626**	1.352	1.100	4.626**	3.657**	1.229	3
1.699	2.662	2.662	2.587	0.674	4.063**	6.847***	1.146	4
0.878	1.905	1.905	0.937	0.619	2.797	2.840	0.199	5
3.419**	1.691	1.691	0.788	0.608	3.677**	3.890**	0.121	6
4.586**	1.763	1.763	0.728	0.390	24.551***	5.987**	0.0875	7
6.763**	2.661	2.661	0.579	1.031	11.544***	2.270	0.198	8
2.105	4.247	4.247	1.013	0.567	5.342	2.792	1.072	9

**$p < 0.05$, ***$p < 0.01$.

Group 1: When the lag length is 6 to 8 years, the null hypothesis of "*lntmcnki* does not Granger-cause *lntmwos*" is rejected, and reverse Granger Causality relationship happens in the lag length of 1 year.

Group 2: When the lag length is 4 years, the null hypothesis of "*lntmwoscn* does not Granger-cause *lntmwos*" is rejected, and reverse Granger Causality relationship happens in the lag length of 1, 3 - 4, 6 - 8 years.

Group 3: When the lag length is 3 years, the null hypothesis of "*lntmwoscnp* does not Granger-cause *lntmwos*" is rejected, and reverse Granger Causality relationship happens in the lag length of 1, 3 - 4, 6 - 7 years.

Group 4: There is no Granger Causality relationship.

Based on our empirical study of the mutual relationship between China's tea medicine research and world's tea medicine research, we conclude the following from a holistic perspective: there is an extremely strong correlation between them in all the three groups. Also, there is a long-run co-integration relationship between China's and world's, indicating a positive statistical linkage between them.

The results from the Granger Causality Test show almost the one-way predictive relationship in these three groups, and each group came to different conclusions. Based on the statistical results, publishing more tea medicine articles to CNKI indexed journals (almost Chinese journals) will promote the world's tea medicine research, while the boom in world tea medicine research will also promote Chinese scholars to publish their tea medicine articles in international journals. We speculate that some Chinese medicine tea research findings may contribute to international journals after published on Chinese journals (CNKI indexed journals), in which there is a 6 - 8 years gap. However, in Group 4, there is no Granger Causality relationship which seems not supporting above conclusion. We conclude such irregular phenomenon into the conducting relationship from tea medicine articles on CNKI indexed journals, global tea medicine articles on Web of Science Core Collection indexed journals, and China's tea medicine articles on Web of Science Core Collection indexed journals. This trend reflects the historical pattern of tea medicine going from China to the world, and thus inspires Chinese scholars to discuss tea medicine in international academic community.

On the other hand, combining the results from ECM model, we are also aware of that the boom in world tea medicine research will reduce the percentage of tea medicine articles published by Chinese scholars. It is possibly caused by several following reasons, scholars from other countries are equally interested in tea medicine, or some of the Chinese scholars still prefer to publish tea medicine articles in CNKI indexed journals.

7. Conclusion

In conclusion, scientific evidence of the health effects of medical tea is mounting, which is reflected in the growing literature in many of the academic databases. We separately reviewed the development of tea medicine in both global and Chinese perspectives and further followed up through bibliometric research methods to

analyze each research trend for comparison. The research result illustrated the interaction between world tea medicine research and China tea medicine research based on different academic databases (WOS Core Collection, CNKI). By examining citation relationships between literature collected by different keywords, we can gain valuable insights into rapidly developing medical tea fields and interaction among different citation indicators.

China has a long history of tea medicine, yet how to guide the development of tea medicine research is still a matter of concern. From three Kingdoms to the present, the history of tea medicine is at least 18 hundred years. By the limitations of the times, the biochemical mechanism of tea, as well as the "tea solution medicinal effect" and other concepts was lack of more in-depth research discussions, and the development of "tea drink" replaced the application of tea medicine in health care, resulting in tea's medicinal status that began to gradually declining. In addition, the efficacy criteria of tea medicine are also problematic and difficult to be supported by evidence-based medical theory. The above-mentioned problems were solved from the perspective of modern medical science, under the principle of evidence-based medicine, with biochemical analysis and the combination of tea ingredients and certain diseases, to clear the obstacles from all sides for the development of tea into medicine and tea medicine.

The trend in tea medicine research has been increasingly focused on understanding the health benefits and bioactive compounds of various tea types and herbal formulations. Literatures emphasize the antioxidant, anti-inflammatory, and antimicrobial properties of tea compounds, such as polyphenols and catechins found in green tea. In contrast, the teas used in TCM come from a wider range of sources and may contain more medically valuable compounds, demonstrating in many records in the ancient Chinese medical books. In modern China, there is also a growing interest in the synergistic effects of combining different tea medical compounds and modern medicines, exploring how these combinations can enhance therapeutic outcomes. Additionally, we also found the influence of Chinese tea medicine research on world tea medicine research through bibliometric approaches. With the excavation of tea medicine components in ancient texts and further integration with modern medicine, we believe that this impetus will become more significant and with more profound results.

The goal of tea medical researchers in China who wish to promote the progress of tea medicine research need to move that science to fruition in the world academic community. To be a leading nation in science and technology, not limited to tea medicine fields, a country must attach great importance to advancing the state of the art in scientific development and manufacturing. One possible way is to enhance and consolidate the international collaboration in the tea medicine research field in order to reduce the gap between publishing on Chinese journals and international journals. Another goal should be to enable policymakers, universities, and research fund sponsors to increase the tea medicine R&D investments in China, such as sponsoring regarding national or provincial research

laboratories, enhancing multi-discipline collaboration among tea medicine, Chemistry, and Biotechnology, or other marketing incentives on transformation of tea medicine achievements or private-government partnerships of various kinds in promoting tea medicine.

Acknowledgements

We thank Prof. Dr. Banghong Fu at University of Science and Technology of China for taking the time to help us during composing this article.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-Tool for Comprehensive Science Mapping Analysis. *Journal of Informetrics, 11,* 959-975. https://doi.org/10.1016/j.joi.2017.08.007

Balentine, D. A., Wiseman, S. A., & Bouwens, L. C. (1997). The Chemistry of Tea Flavonoids. *Critical Reviews in Food Science & Nutrition, 37,* 693-704.

Bayliak, M. M., Dmytriv, T. R., Melnychuk, A. V., Strilets, N. V., Storey, K. B., & Lushchak, V. I. (2021). Chamomile as a Potential Remedy for Obesity and Metabolic Syndrome. *EXCLI Journal, 20,* 1261-1286.

Benzie, I. F., & Wachtel-Galor, S. (2011). *Herbal Medicine: Biomolecular and Clinical Aspects*. CRC Press/Taylor & Francis.

Cai, S. et al. (2020). Immunomodulatory Effects of Tea. *Chinese Tea, 42,* 1-12.

Caruana, M., & Vassallo, N. (2015). Tea Polyphenols in Parkinson's Disease. In N. Vassallo (Ed.), *Natural Compounds as Therapeutic Agents for Amyloidogenic Diseases* (pp. 117-137). Springer International Publishing. https://doi.org/10.1007/978-3-319-18365-7_6

Crozier, A., Jaganath, I. B., & Clifford, M. N. (2009). Dietary Phenolics: Chemistry, Bioavailability and Effects on Health. *Natural Product Reports, 26,* 1001-1043.

Davidson, J. E. H., Hendry, D. F., Srba, F., & Yeo, S. (1978). Econometric Modelling of the Aggregate Time-Series Relationship between Consumers' Expenditure and Income in the United Kingdom. *The Economic Journal, 88,* 661-692. https://doi.org/10.2307/2231972

Del Rio, D., Stewart, A. J., Mullen, W., Burns, J., Lean, M. E., Brighenti, F., & Crozier, A. (2004). HPLC-MSn Analysis of Phenolic Compounds and Purine Alkaloids in Green and Black Tea. *Journal of Agricultural and Food Chemistry, 52,* 2807-2815.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association, 74,* 427-431. https://doi.org/10.1080/01621459.1979.10482531

Dickey, D. A., & Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica, 49,* 1057-1072. https://doi.org/10.2307/1912517

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica, 55,* 251-276. https://doi.org/10.2307/1913236

Finger, A., Kuhr, S., & Engelhardt, U. H. (1992). Chromatography of Tea Constituents. *Journal of Chromatography A, 624,* 293-315.

Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. *Econometrica, 37,* Article No. 424. https://doi.org/10.2307/1912791

Granger, C. W. J. (1980). Testing for Causality: A Personal Viewpoint. *Journal of Economic Dynamics and Control, 2,* 329-352. https://doi.org/10.1016/0165-1889(80)90069-x

He, Z. et al. (2020). Thoughts on the Study of Clinical Evaluation of Traditional Chinese Medicine. *Chinese Journal of Ethnomedicine and Ethnopharmacy, 29,* 115-118.

Jiang, Q. et al. (2019). Philosophical Connotation of "Homology of Medicine and Tea" and Its Influence on Traditional Chinese Medicine. *Journal of The Fourth Military Medical University, 10,* 16-20.

Jiang, Y. (2010). 110 Cases of Herpes Zoster treated with Longdan Xiegan Decoction Combined with Chuanxiong Chatiao Powder. *Journal of Emergency in Traditional Chinese Medicine, 19,* 1431-1432.

Khan, S. S., Najam, R., Anser, H., Riaz, B., & Alam, N. (2014). Chamomile Tea: Herbal Hypoglycemic Alternative for Conventional Medicine. *Pakistan Journal of Pharmaceutical Sciences, 27,* 1509-1514.

Kónya, L. (2006). Exports and Growth: Granger Causality Analysis on OECD Countries with a Panel Data Approach. *Economic Modelling, 23,* 978-992.

Lan, Y. et al. (2020). Research on the Origin and Evolution of Tea Medicine Formula. *Journal of Beijing University of Traditional Chinese Medicine, 43,* 186-191.

Leng, J. (2005). Clinical Investigation on the Treatment of Herpes Zoster by the Combination of Longdan Xiegan Decoction and Chuanxiong Chatiao Powder. *Journal of Liaoning College of Traditional Chinese Medicine, 1,* 54.

Luan, C., Deng, S., & Allison, J. R. (2022). Mutual Granger "Causality" between Scientific Instruments and Scientific Publications. *Scientometrics, 127,* 6209-6229. https://doi.org/10.1007/s11192-022-04516-1

Nantz, M. P., Rowe, C. A., Bukowski, J. F., & Percival, S. S. (2009). Standardized Capsule of *Camellia sinensis* Lowers Cardiovascular Risk Factors in a Randomized, Double-Blind, Placebo-Controlled Study. *Nutrition, 25,* 147-154.

Phillips, P. C. B., & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrika, 75,* 335-346. https://doi.org/10.1093/biomet/75.2.335

Price, D. D. S. (1976). A General Theory of Bibliometric and Other Cumulative Advantage Processes. *Journal of the American Society for Information Science, 27,* 292-306.

Schwert, G. W. (1989). Why Does Stock Market Volatility Change over Time? *The Journal of Finance, 44,* 1115-1153.

Shen, X. et al. (2019). Exploration of Extraction and Stability of Tea Polyphenols in Keemun Black Tea. *Science and Technology Innovation, 35,* 7-9.

Srivastava, J. K., Shankar, E., & Gupta, S. (2010). Chamomile: A Herbal Medicine of the Past with a Bright Future (Review). *Molecular Medicine Reports, 3,* 895-901. https://doi.org/10.3892/mmr.2010.377

Tan, J., Engelhardt, U. H., Lin, Z., Kaiser, N., & Maiwald, B. (2017). Flavonoids, Phenolic Acids, Alkaloids and Theanine in Different Types of Authentic Chinese White Tea Samples. *Journal of Food Composition and Analysis, 57,* 8-15. https://doi.org/10.1016/j.jfca.2016.12.011

Tao, Y. (2016). What Is Tea Medicine Therapy? How to Choose to Drink It? *Shanghai Journal of Traditional Chinese Medicine, 7,* 4.

Wang, J., & Sporns, P. (2000). MALDI-TOF MS Analysis of Food Flavonol Glycosides. *Journal of Agricultural and Food Chemistry, 48,* 1657-1662.

Wang, M., Liao, Z., Mao, D., Zhang, Q., Li, Y., Yu, E. et al. (2017). Application of Granger Causality Analysis of the Directed Functional Connection in Alzheimer's Disease and Mild Cognitive Impairment. *Journal of Visualized Experiments,* 126, e56015. https://doi.org/10.3791/56015

Wang, S., & Lai, J. (1995). Dietary Fiber in Tea and Its Fitness Effects. *Tea Processing in China, 2,* 37-38+47.

Wu, X., & Yan, S. (2017). Tea Medicine Research under the Background of Tea Culture Prosperity in the Northern Song Dynasty. *Chinese Medical Culture, 12,* 44-47.

Xi, X. (2017). *A Literature Study of Tea Properties, Tea Effects and Tea Uses*. Beijing University of Traditional Chinese.

Xi, X. et al. (2016). The Literature of "Taking Medicine without Tea". *Journal of Beijing University of Traditional Chinese Medicine, 39,* 985-988.

Xi, X. et al. (2017). Tea Antidote to Drug Poisoning Examination and Debate. *Journal of Traditional Chinese Medicine, 58,* 79-81.

Xiao, Z. et al. (2018). Brief Description of the Tea Culture in Yuan Dynasty. *China Tea Processing, 2,* 61-65+69.

Ye, X. et al. (2020). Clinical Study on Ultramicro Acupotomy Combined with Gabapentin in the Treatment of Post-Herpetic Neuralgia. *Journal of Clinical Acupuncture and Moxibustion, 36,* 5-9.

Yi, H., & Xi, Z. (2008). Trends of DDT Research during the Period of 1991 to 2005. *Scientometrics, 75,* 111-122. https://doi.org/10.1007/s11192-007-1828-3

Zhang, C., & Xiao, Z. (2019). An Overview of Chinese Tea Medicine Development. *Agricultural Archaeology, 5,* 212-217.

Zhang, D. (2020). Clinical Study on Daqing Lianqiao Tang for Herpes Zoster and Its Effect on Levels of Inflammatory Factors in Serum. *Journal of New Chinese Medicine, 52,* 109-111.

Zhao, H., & Jiang, G. (1985). Shifting of World's Scientific Center and Scientists' Social Ages. *Scientometrics, 8,* 59-80. https://doi.org/10.1007/bf02025221

Zhou, X. (1993). A Brief Discussion of Tea Medicines. *Agricultural Archaeology, 2,* 154-157+130.

Zhu, B. (2018). The Origin of Tea Substitute, Mixed Tea and Tea Medicine. *Agricultural Archaeology, 2,* 211-214.