



Review Article

Research progress and application of food and medicine homology plants in the treatment of functional gastrointestinal disorders

Xue-Ying Xu¹, Shu-Jing Zhang^{2,3}, Chu-Chu Hu², Yi Wang^{1,2,3}, Yu Tang^{1,2} (✉), Ying-Chao Wang^{1,2} (✉)

¹ Pharmaceutical Informatics Institute, College of Pharmaceutical Sciences, Zhejiang University, Hangzhou 310058, China

² Innovation Institute for Artificial Intelligence in Medicine, Zhejiang University, Hangzhou 310018, China

³ Jinan Microecological Biomedicine Shandong Laboratory, Jinan 250118, China

Received: 9 August 2024 / Revised: 22 September 2024 / Accepted: 5 October 2024

Abstract: Functional gastrointestinal disorders (FGIDs) are a group of digestive disorders affecting nearly 40% of the global population. In recent years, studies have demonstrated the significant therapeutic effects of a wealth of herbal medicines and their bioactive components in the treatment of FGIDs. Notably, among these herbal preparations, food and medicine homology (FMH) plants account for a significant portion. This review focuses on the use of FMH plants and FMH-containing formulas for the treatment of FGIDs, provides an overview of their pharmacological effects, and analyzes the modeling and efficacy of those formulas, FMH extracts, and corresponding components in the treatment of gastrointestinal disorders. This review aims to serve as a reference for the research and application of FMH used to treat FGIDs.

Keywords: functional gastrointestinal disorders (FGIDs); food and medicine homology; TCM formulas; Chinese medicine

Citation: Xu X.Y., Zhang S. J., Hu C. C., et al. Research progress and application of food and medicine homology plants in the treatment of functional gastrointestinal disorders. *Food & Medicine Homology*, 2027, 4: 9420148. <https://doi.org/10.26599/FMH.2027.9420148>

1 Introduction

Functional gastrointestinal disorders (FGIDs), also known as disorders of gut-brain interactions (DGBI), are a group of chronic or recurrent gastrointestinal syndromes resulting from the interplay of physiologic, psychosomatic, and societal factors. According to the global epidemiologic data^[1,2], FGIDs occur frequently with a prevalence of nearly 40% worldwide, and have a complex pathophysiology involving dysregulation of the gut-brain axis, visceral allergy, gastrointestinal dyskinesia, low-grade intestinal inflammation, intestinal ecological dysregulation, and psychological disorders^[3-6]. Basically, FGIDs involve dysfunctions in how the gastrointestinal tract works rather than structural or biochemical abnormalities. As a result, X-rays, blood tests, and endoscopy often yield essentially normal results.

The Rome Diagnostic Criteria, the currently recognized classification system of FGIDs, was initially proposed in 1990 and has undergone three subsequent revisions based on expert consensus and relevant evidence. It is now commonly used as the Rome IV diagnostic questionnaire^[7-10]. The criteria claimed that FGIDs include 33 adult FGIDs (Table 1), which are categorized by anatomical location as esophageal disorders, gastroduodenal disorders, intestinal disorders, centrally mediated gastrointestinal pain disorders, gallbladder and sphincter of Oddi disorders, and anorectal disorders.

Epidemiologic data published in the Lancet's Functional Gastrointestinal Disease Album^[1] indicate that the most prevalent

FGIDs include functional dyspepsia (FD), irritable bowel syndrome (IBS), and functional constipation (FC). The morbidity of these disorders in the general population is quite high, with almost half of the population being likely to meet the diagnostic criteria for falling into at least one of the categories at any given time^[11].

The term "Food and Medicine Homology (FMH)" refers to edible herbal materials that can be employed both as food and medicine, which provide not only essential nutrients for the human body, but also regulate bodily functions through preventing and treating diseases based on daily dietary intake^[12,13]. Since ancient times, China has had the concept of FMH. For instance, "Huangdi Neijing", "Divine Farmer's Materia Medica", "Materia Medica for Dietary Therapy", and "Compendium of Materia Medica", etc., recorded the practice of employing some specific foods as drugs to adjust body functions^[14,15].

Both traditional Chinese medicine (TCM) and FMH hold the concept that "prevention is better than cure" and advocate for the role of healthy daily diet and lifestyles in preventing diseases. Furthermore, TCM and FMH regard the human body as a unified whole, where the zang-fu organs are interrelated. Medicating the spleen and stomach is not solely focused on their individual functions, but rather aims at holistic regulation, balancing the qi, blood, yin, yang, and zang-fu organs, thereby achieving therapeutic effects^[16]. As mentioned above, FGIDs are complex due to involving interactions among various digestive organs and the intertwining of multiple metabolic pathways.

Table 1 Rome IV Classification of the Functional Gastrointestinal Disorders-Disorders of Gut-Brain Interaction

A. Esophageal disorders (5 types)	B. Gastroduodenal disorders (8 types)	C. Bowel disorders (9 types)
	B1. Functional dyspepsia	C1. Irritable Bowel Syndrome, IBS
	B1a. Postprandial distress syndrome	C1a. IBS with predominant constipation
	B1b. Epigastric pain syndrome	C1b. IBS with predominant diarrhoea
	B2. Belching disorders	C1c. IBS with mixed bowel habits
A1. Functional chest pain	B2a. Excessive supragastric belching	C1d. IBS unclassified
A2. Functional heartburn	B2b. Excessive gastric belching	C2. Functional constipation
A3. Reflux hypersensitivity	B3. Nausea and vomiting disorders	C3. Functional diarrhoea
A4. Globus	B3a. Chronic nausea vomiting syndrome	C4. Functional abdominal bloating or distension
A5. Functional dysphagia	B3b. Cyclic vomiting syndrome	C5. Unspecified functional bowel disorder
	B3c. Cannabinoid hyperemesis syndrome	C6. Opioid-induced constipation
	B4. Rumination syndrome	
D. Centrally mediated disorders of gastrointestinal pain (2 types)	E. Gallbladder and sphincter of Oddi disorders (3 types)	F. Anorectal disorders (6 types)
		F1. Faecal incontinence
D1. Centrally mediated abdominal pain syndrome	E1. Biliary pain	F2. Functional anorectal pain
D2. Narcotic bowel syndrome or opioid-induced gastrointestinal hyperalgesia	E1a. Functional gallbladder disorder	F2a. Levator ani syndrome
	E1b. Functional biliary sphincter of Oddi disorder	F2b. Unspecified functional anorectal pain
	E2. Functional pancreatic sphincter of Oddi disorder	F2c. Proctalgia fugax
		F3. Functional defecation disorders
		F3a. Inadequate defecation propulsion
		F3b. Dyssynergic defaecation
G. Childhood functional gastrointestinal disorders: neonate/toddler	H. Childhood functional gastrointestinal disorders: child/adolescent	
	H1. Functional nausea and vomiting disorders	
	H1a. Cyclic vomiting syndrome	
	H1b. Functional nausea and functional vomiting	
	H1b1. Functional nausea	
	H1b2. Functional vomiting disorders	
	H1c. Rumination syndrome	
	H1d. Aerophagia	
G1. Infant regurgitation	H2. Functional abdominal pain disorders	
G2. Rumination syndrome	H2a. Functional dyspepsia	
G3. Cyclic vomiting syndrome constipation	H2a1. Postprandial distress syndrome	
G4. Infant colic	H2a2. Epigastric pain syndrome	
G5. Functional diarrhea	H2b. Irritable bowel syndrome	
G6. Infant dyschezia	H2c. Abdominal migraine	
G7. Functional	H2d. Functional abdominal pain-not otherwise specified	
	H3. Functional defecation	
	H3a. Functional constipation	
	H3b. Non-retentive fecal incontinence	

FMH has therapeutic advantages in the prevention and treatment of gastrointestinal diseases. In terms of safety, as a part of our daily diet, FMH materials are generally safer with fewer side effects. In treatment philosophy, FMH emphasizes overall health and balance, and regulates the body's physiological functions comprehensively through a reasonable diet. Regarding medication and therapeutic effects, FMH is relatively simple, easy to integrate into daily life, and has high patient compliance. FMH emphasizes long-term dietary adjustments, helping patients to establish healthy dietary habits and maintain gastrointestinal health^[17]. In conclusion, FMH has significant importance in the prevention and treatment of gastrointestinal diseases.

This article will focus on FGIDs and FMH; the organization can best be described as Fig. 1.

2 Explanation of FD, IBS, FC in Chinese medicine

FD results from a combination of factors such as emotional disorders, overwork, innate constitutional insufficiency, dietary irregularities, the infection of pathogenic qi. According to the *Expert consensus on Traditional Chinese Medicine Diagnosis and*

Treatment of Irritable Bowel Syndrome (2017), IBS is often induced by factors including but not limited to innate constitutional insufficiency, acquired disordered nourishment, emotional disorder, dietary irregularities, and the infection of pathogenic qi factors. Weakness of the spleen and stomach and/or liver incapacitation of the free flow of qi are important links in the pathogenesis of IBS. Yang deficiency of the spleen and kidney and combined deficiency and excess are the key factors leading to the persistent and difficult-to-treat nature of the condition. FC in TCM falls under categories such as "constipation", "difficulty in defecation", "splenic constipation", "difficulty passing hard stools", etc., with main causes including dietary irregularities, emotional disorders, sedentary lifestyle, overwork, senility, post-sickness and postpartum conditions, and side effects from medication administration, etc. In addition, some patients have a congenital constitutional insufficiency. The related consensus classified the three diseases into corresponding syndrome types and proposed corresponding treatment plans (Table 2).

3 Catalogue of medicine and food homology

On November 17, 2023, November 25, 2019 and August 26,

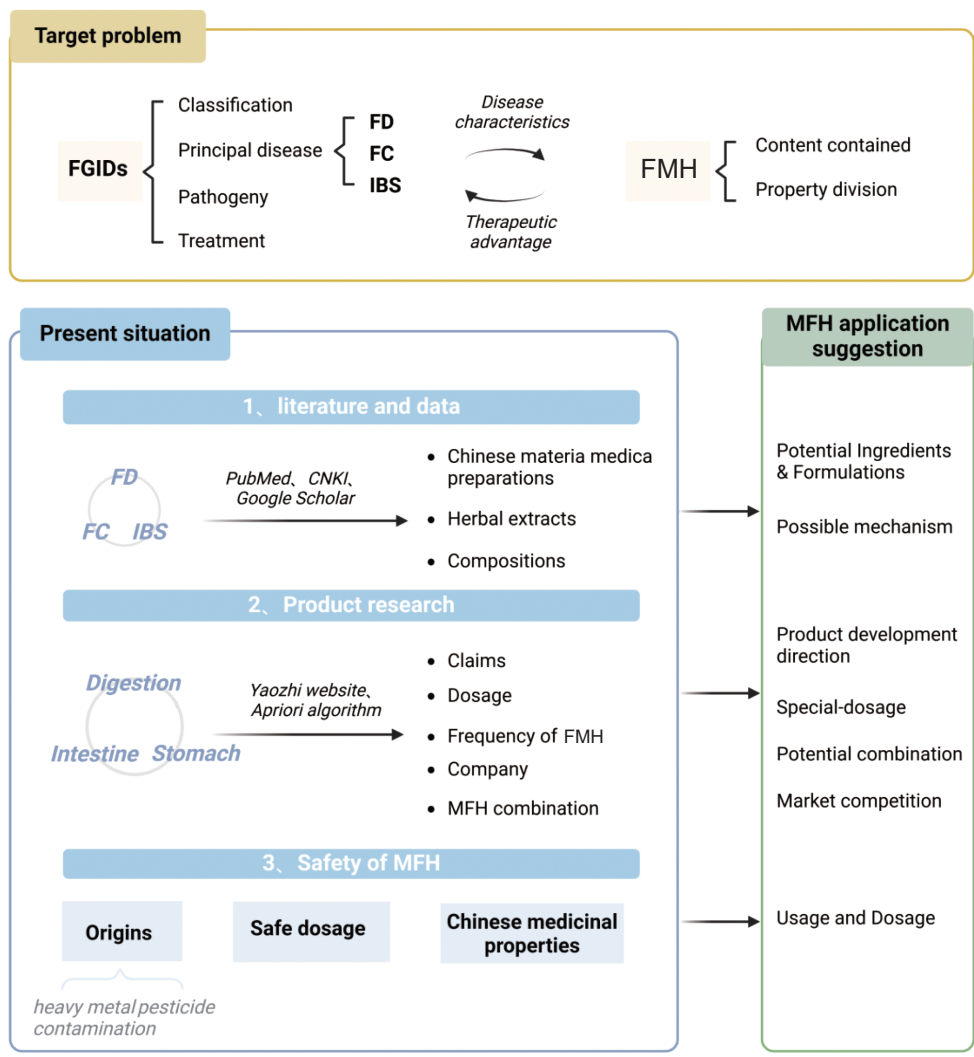


Figure 1 Article structure.

Table 2 Classification of corresponding types of evidence and treatments according to the consensus of experts on Chinese medicine diagnosis and treatment^[18]

Reference	Pattern	Treatment
Interpretation of the experts consensus on traditional chinese medicine diagnosis and treatment of functional dyspepsia(2023) ^[19]	Spleen deficiency with qi stagnation pattern	Strengthen the spleen and harmonize the stomach, circulate qi and harmonize the stomach
	Disharmony between the liver and stomach pattern	Circulate qi and Relieve stagnation, harmonize the stomach and downregulate qi drug
	Damp heat in the spleen and stomach pattern	Clear heat and dry dampness, harmonize the middle jiao and regulate qi
	Yang deficiency of the spleen and stomach pattern	Strengthen the spleen and harmonize the stomach, formulas that warm the middle jiao and remove cold
	Combined cold and heat pattern	Pungent opening and bitter descending, harmonize the stomach and resolve stagnation
Expert Consensus on Traditional Chinese Medicine Diagnosis and Treatment of Irritable Bowel Syndrome (2017) ^[20]	Liver hyperactivity with spleen deficiency pattern	Tonify the spleen and kidney
	Spleen deficiency with dampness pattern	Strengthen the spleen and supplement qi, transform dampness and stop diarrhea
	Yang deficiency of the spleen and kidney pattern	Tonify the spleen and kidney
	Damp heat in the spleen and stomach pattern	Clear heat and drain dampness
	Combined cold and heat pattern	Balance and regulate cold and heat, formulas that warm the middle jiao and supplement qi
IBS with predominant diarrhoea	Liver qi stagnation pattern	Soothe the liver and regulate qi, regulate qi and resolve stagnation
	Excess heat in the stomach and intestines pattern	Moisten the intestine and clear heat, moisten dryness and promote bowel movements
	Intestinal dryness due to yin deficiency pattern	Nourish yin and clear fire, moisten dryness and promote bowel movements
	Yang deficiency of the spleen and kidney pattern	Moisten dryness and promote bowel movements
	Deficiency of the spleen and lung pattern	Supplement qi and moisten the intestine

(Continued)

Reference	Pattern	Treatment
Consensus opinions on the diagnosis and treatment of functional constipation by integrated traditional Chinese and Western medicine (2017) ^[21]	Heat accumulation	Moisten the intestine and clear heat
	Cold accumulation	Warm and resolve masses
	Qi impediment	Regulate qi and resolve stagnation
	Qi deficiency	Supplement qi and moisten the intestine
	Blood deficiency	Nourish yin and blood, moisten dryness and promote bowel movements
	Yin deficiency	Nourish yin and moisten dryness
	Yang deficiency	Moisten dryness and promote bowel movements

2024 China National Health Commission (NHC) announced to update to the *Catalogue of Substances Traditionally Considered as Both Food and Chinese Medicine* by adding eighteen new substances. Together with *Notice from the Ministry of Health on Further Regulating the Management of Health Food Ingredients* (Weifa Jianfa (2002) No. 51), the currently cumulative number of approved substances is therefore 106.

As per the standard of *Chinese Materia Medica* (National

Higher Education of Traditional Chinese Medicine Industry “14th Five-Year Plan” Teaching Material)^[22], FMH materials in the present study were categorized accordingly (Table 3). Some of the materials that are not included in this book are sorted according to the guidelines of the *Pharmacopoeia of the People's Republic of China*^[23] and the scientific properties of those materials, as shown in the table below.

Modern Chinese medicine divides Chinese materia medica into

Table 3 Classification of FMH^[24]

Category	Species	Proportion	Categorization of FMH by <i>Chinese Materia medica</i> [Latin (English, Chinese)]	Categorization of FMH by <i>Pharmacopoeia</i> [Latin (English, Chinese)]
Tonic medicines	24	22.64%	<i>Astragalus membranaceus</i> (Astragalus root, Huangqi), <i>Dolichos lablab</i> L. (Lablab, Bai bian dou), <i>Glycyrrhiza uralensis</i> Fisch., <i>Glycyrrhiza inflata</i> Bat., <i>Glycyrrhiza glabra</i> L. (Licorice root, Gan cao), <i>Ziziphus jujuba</i> Mill. (Chinese date, Da zao), <i>Codonopsis pilosula</i> (Franch.) Nannf., <i>Codonopsis pilosula</i> Nannf. var. <i>Modesta</i> (Nannf.) L. T. Shen, <i>Codonopsis tangshen</i> Oliv. (Codonopsis root, Dang shen), <i>Dioscorea opposita</i> Thunb. (Dioscorea rhizome, Shan yao), <i>Apis mellifera</i> L., <i>Apis cerana</i> Fabricius (Honey, Feng mi), <i>Hippophae rhamnoides</i> L. (Sea buckthorn fruit, Sha ji), <i>Panax quinquefolium</i> L. (American ginseng, Xi yang shen) <i>Cistanche deserticola</i> Y. C. Ma, <i>Cistanche tubulosa</i> (Schenk) Wight (Desert-living cistanche, Rou cong rong), <i>Angelica sinensis</i> (Oliv.) Diels (Pubescent angelica root, Dang gui), <i>Equus asinus</i> L. (Donkey-hide glue, E jiao), <i>Dimocarpus longan</i> Lour. (Longan aril, Long yan rou), <i>Morus alba</i> L. (Mulberry fruit, Sang shen), <i>Lycium barbarum</i> L. (Lycium fruit, Gou qi zi), <i>Lilium lancifolium</i> Thunb., <i>Lilium brownii</i> F. E. Brown var. <i>viridulum</i> Baker, <i>Lilium pumilum</i> DC. (Lily bulb, Bai he), <i>Polygonatum kingianum</i> Coll. et Hemsl., <i>Polygonatum sibiricum</i> Red., <i>Polygonatum cyrtoneura</i> Hua (Polygonatum rhizome, Huang jing), <i>Polygonatum odoratum</i> (Mill.) Druce (Polygonatum, Yu zhu), <i>Sesamum indicum</i> L. (Black sesame seed, Hei zhi ma), <i>Asparagus cochinchinensis</i> (Lour.) Merr. (Asparagus tuber, Tian dong), <i>Ophiopogon japonicus</i> (L. f.) Ker Gawl. (Ophiopogon tube, Mai dong)	<i>Eucommia ulmoides</i> Oliv. (Eucommia bark leaf, Du zhong ye), <i>Dendrobium officinale</i> Kimura et Migo (Dendrobium, Tie pi shi hu), <i>Alpinia oxyphylla</i> Miq. (Sharpleaf galangal fruit, Yi zhi ren)
Interior heat-clearing medicines	12	11.32%	<i>Gardenia jasminoides</i> Ellis (Gardenia fruit, Zhizi), <i>Lophatherum gracile</i> Brongn. (Lophatherum stem and leaf, Dan zhu ye), <i>Cassia obtusifolia</i> L., <i>Cassia tora</i> L. (Cassia seed, Jue ming zi), <i>Phragmites communis</i> Trin. (Reed rhizome, Lu gen), <i>Lonicera japonica</i> Thunb. (Japanese honeysuckle flower, Jin yin hua), <i>Taraxacum mongolicum</i> Hand., <i>Taraxacum borealisinense</i> Kitam. (Dandelion, Pu gong ying), <i>Houttuynia cordata</i> Thunb. (Houttuynia, Yu xing cao), <i>Canarium album</i> Raeusch. (Chinese white olive, Qing guo), <i>Rehmannia glutinosa</i> (Gaertn.) Libosch. ex Fisch. & C. A. Mey. (Rehmannia root, Di huang)	<i>Phyllanthus emblica</i> L. (Emblc leaf-flower fruit, Yu gan zi), <i>Nelumbo nucifera</i> Gaertn. (Lotus leaf, He ye), <i>Portulaca oleracea</i> L. (Purslane, Ma chi xian)
Exterior-releasing medicines	9	8.49%	<i>Perilla frutescens</i> (L.) Britt. (Perilla leaf, Zi su), <i>Angelica dahurica</i> (Fisch. ex Hoffm.) Benth. et Hook. f. (Dahurian angelica root, Bai zhi), <i>Zingiber officinale</i> Rosc. (Fresh ginger rhizome, Sheng jiang), <i>Mosla chinensis</i> Maxim. (Mosla, Xiang ru), <i>Mentha haplocalyx</i> Briq. (Mint, Bo he), <i>Morus alba</i> L. (Mulberry leaf, Sang ye), <i>Chrysanthemum morifolium</i> Ramat. (Chrysanthemum flower, Ju hua), <i>Pueraria lobata</i> (Willd.) Ohwi (Pueraria, Ge gen), <i>Glycine max</i> (L.) Merr. (Prepared soybean, Dan dou chi)	/
Qi-regulating medicines	7	6.60%	<i>Citrus medica</i> L. var. <i>sarcodactylis</i> Swingle (Finger citron, Fo shou), <i>Citrus reticulata</i> Blanco (Aged tangerine peel, Ju pi), <i>Allium macrostemon</i> Bge., <i>Allium chinense</i> G. Don (Chinese garlic, Xie bai), <i>Canavalia gladiata</i> (Jacq.) DC (Sword bean, Dao dou), <i>Citrus medica</i> L., <i>Citrus wilsonii</i> Tanaka (Citron fruit, Xiang yuan)	<i>Citrus aurantium</i> L. var. <i>Amara</i> Engl. (Bitter orange flower, Dai dai hua), <i>Citrus reticulata</i> Blanco (Red tangerine peel, Ju hong)
Astringent medicines	6	5.66%	<i>Prunus mume</i> (Sieb.) Sieb. et Zucc. (Mume fruit, Wu mei), <i>Myristica fragrans</i> Houtt. (Nutmeg, Rou dou kou), <i>Nelumbo nucifera</i> Gaertn. (Otus seed, Lian zi), <i>Euryale ferox</i> Salisb. (Euryale seed, Qian shi), <i>Cornus officinalis</i> Sieb. et Zucc. (Asiatic cornelian cherry fruit, Shan zhu yu), <i>Rubus chingii</i> Hu (Rubus, Fu pen zi)	

(Continued)

Category	Species	Proportion	Categorization of FMH by Chinese Materia medica [Latin (English, Chinese)]	Categorization of FMH by Pharmacopoeia [Latin (English, Chinese)]
Urination-promoting and dampness-draining medicines	6	5.66%	<i>Poria cocos</i> (Schw.) Wolf (Poria, Fu ling), <i>Coix lacryma-jobi</i> L. var. <i>ma-yuen</i> (Roman.) Stapf (Coix seed, Yi yi ren), <i>Hovenia dulcis</i> Thunb., <i>Hovenia acerba</i> Lindl., <i>Hovenia trichocarpa</i> Chun et Tsiang (Raisin tree seed, Zhi ju zi)	<i>Vigna umbellata</i> Ohwi et Ohashi, <i>Vigna angularis</i> Ohwi et Ohashi (Rice bean, Chi xiao dou), <i>Cichorium glandulosum</i> Boiss. et Huet, <i>Cichorium intybus</i> L. (Chicory, Ju ju), <i>Dolichos lablab</i> L. (Lablab flower, Bai bian dou hua)
Digestion-promoting medicines	4	3.77%	<i>Crataegus pinnatifida</i> Bge. var. <i>major</i> N. E. Br., <i>Crataegus pinnatifida</i> Bge. (Hawthorn fruit, Shan zha), <i>Raphanus sativus</i> L. (Radish seed, Lai fu zi), <i>Gallus gallus domesticus</i> Brisson (Gizzard lining, Ji nei jin), <i>Hordeum vulgare</i> L. (Barley sprout, Mai ya)	<i>Agkistrodon halys</i> (Pallas pit viper, Fu she), <i>Chaenomeles speciosa</i> (Sweet) Nakai (Chaenomeles fruit, Mu gua)
Wind-eliminating and dampness-resolving medicines	3	2.83%	<i>Zaocys dhumnades</i> (Cantor) (Zaocys, Wu shao she)	
Blood-circulating and blood stasis-resolving medicines	3	2.83%	<i>Curcuma longa</i> L. (Turmeric rhizome, Jiang huang), <i>Crocus sativus</i> L. (Saffron, Xi hong hua), <i>Prunus persica</i> (L.) Batsch, <i>Prunus davidiana</i> (Carr.) Franch. (Peach kernel, Tao ren)	
Tranquilizing medicines	3	2.83%	<i>Pogostemon cablin</i> (Blanco) Benth. (Patchouli, Huo xiang), <i>Amomum villosum</i> Lour., <i>Amomum villosum</i> Lour. var. <i>xanthioides</i> T.L. Wu et Senje, <i>Amomum longiligulare</i> T.L. Wu (Amomum fruit, Sha ren), <i>Amomum tsao-ko</i> Crevost et Lemaire (Tsaoko fruit, Cao guo)	
Purgative medicines	2	1.89%	<i>Cannabis sativa</i> L. (Hemp seed, Huo ma ren), <i>Prunus humilis</i> Bge., <i>Prunus japonica</i> Thunb., <i>Prunus pedunculata</i> Maxim. (Bush cherry pit, Yu li ren)	
Interior-warming medicines	9	8.49%	<i>Eugenia caryophyllata</i> Thunb. (Clove, Ding xiang), <i>Foeniculum vulgare</i> Mill. (Fennel, Xiao hui xiang), <i>Alpinia officinarum</i> Hance (Galangal, Gao liang jiang), <i>Zanthoxylum schinifolium</i> Sieb. et Zucc., <i>Zanthoxylum bungeanum</i> Maxim. (Zanthoxylum, Hua jiao), <i>Piper nigrum</i> L. (Pepper, Hei hu jiao), <i>Piper longum</i> L. (Long pepper fruit, Bi bo)	<i>Illicium verum</i> Hook. f. (Chinese star anise, Ba jiao hui xiang), <i>Cinnamomum cassia</i> Presl (Cinnamon bark, Rou gui), <i>Kaempferia galanga</i> L. (Galanga resurrection lily rhizome, Shan nai)
Cough-stopping and panting-alleviating medicines, Phlegm-transforming medicines	9	8.49%	<i>Platycodon grandiflorum</i> (Jacq.) A. DC. (Platycodon root, Jie geng), <i>Sterculia lychnophora</i> Hance (Sterculia seed, Pang da hai), <i>Laminaria japonica</i> Aresch., <i>Ecklonia kurome</i> Okam. (Kelp, Kun bu), <i>Ginkgo biloba</i> L. (Ginkgo seed, Bai guo), <i>Prunus armeniaca</i> L. var. <i>ansu</i> Maxim., <i>Prunus sibirica</i> L., <i>Prunus mandshurica</i> (Maxim.) Koehne, <i>Prunus armeniaca</i> L. (Bitter apricot seed, Xing ren), <i>Perilla frutescens</i> (L.) Britt. (Perilla seed, Zi su zi), <i>Citrus grandis</i> 'Tomentosa', <i>Citrus grandis</i> (L.) Osbeck (Pomelo flavedo, Hua ju hong)	<i>Brassica juncea</i> (L.) Czern. et Coss. (Sinapis Semen, Huang jie zi), <i>Siraitia grosvenorii</i> (Swingle) C. Jeffrey ex A. M. Lu et Z. Y. Zhang (Momordica fruit, Luo han guo)
Haemostatic medicines	4	3.77%	<i>Sophora japonica</i> L. (Sophora flower, Huai hua), <i>Imperata cylindrica</i> Beauv. var. <i>major</i> (Nees) C. E. Hubb. (Imperata rhizome, Bai mao gen), <i>Cirsium setosum</i> (Willd.) MB. (Small thistle, Xiao ji)	<i>Styphnolobium japonicum</i> (L.) Schott (Sophora flower-bud, Huai mi)
Tranquillizing medicines	2	1.89%	<i>Ganoderma lucidum</i> (Leyss. ex Fr.) Karst., <i>Ganoderma sinense</i> Zhao (Ganoderma, Ling zhi), <i>Ziziphus jujuba</i> Mill. var. <i>spinosa</i> (Bunge) Hu ex H. F. Chou (Spine date seed, Suan zao ren)	
Liver-soothing and wind-extinguishing medicines	2	1.89%	<i>Ostrea gigas</i> Thunberg, <i>Ostrea talienwhanensis</i> Crosse, <i>Ostrea rivularis</i> Gould (Oysters, Mu li), <i>Gastrodia elata</i> Bl. (Tall gastrodia tuber, Tian ma)	
Parasite-expelling medicines	1	0.94%	<i>Torreya grandis</i> Fort. (Torreya seed, Fei zi)	

21 categories. As listed in Table 3, most of the FMH materials are herbal tonics, heat-clearing medicines, exterior-releasing medicines, and interior-warming medicines. On the other hand, digestion-promoting medicines, purgative medicines, qi-

regulating medicines, interior heat-clearing medicines, dampness-transforming medicines, tonic medicines, blood-circulating and stasis-transforming medicines^[25] are all relevant to the treatment of gastrointestinal disorders.

4 Therapeutic effects of TCM on FGIDs

4.1 Chinese materia medica preparations and Chinese proprietary medicines

Compound preparation (Chinese materia medica Preparations & Chinese proprietary Medicines), consisting of a series of TCMs, is the primary TCM application in clinical practice. There are a large number of meta studies on the treatment of FGIDs through TCM preparations and proprietary medicines. The composition of TCM preparations is complex; it's necessary to clarify the role of each drug, which is actually in line with the compatibility principle of principal, assistant, complement, and guide in TCM. This paper gives priority to meta-analysis, in which FMH materials account for more than 50% of the substances in the formula analyzed. Finally, four classic decoctions, namely Banxia Xiexin Decoction, Jianpi Yiqi Decoction, Xiangsha Liujunzi Decoction, and Sijunzi decoction, were selected for the study (Table 4).

From the existing research data, we can clearly conclude that in the treatment of diseases such as FD and IBS, TCM compound preparations show similar therapeutic effects when compared with Western medicines. Additionally, treatment involving only TCM exhibited better effects in terms of certain indicators in some cases. With respect to the studies of FC, little research on FMH materials was performed, let alone relevant meta-analysis. In the randomized controlled studies available related to constipation, the percentage of FMH materials in the formulas is usually low^[34].

4.2 Herbal extracts

In the field of FGID research, studies are focused on the efficacy evaluation of using Western medicine and TCM preparations. In contrast, clinical studies on the extracts of single herbs or combinations of multi-extracts are relatively scarce.

As shown in Table 5, clinical research revealed that the extracts of ginger, mint, and amomum fruit can effectively alleviate and treat the symptoms related to FD. Meanwhile, that aloe extract showed significant effects in the treatment of IBS. When it comes to animal experiments, dandelion, pubescent angelica root, desert-living cistanche, hawthorn fruit, and cassia seed have shown positive effects in the treatment of FC. Psoralea fruit and desert-living cistanche, and cinnamon bark have also been proven to have a significant promoting effect in the treatment of IBS. emblic leaf-flower fruit has potential therapeutic effects for treating FD.

4.3 Compositions

The chemical compositions of TCMs are complex, and it is of crucial meaning to disclose the pharmacodynamic material basis of TCMs and their mechanism of action in the treatment of FGIDs^[48]. The present review therefore organized the research results of the active ingredients from FMH materials and their mechanisms of action in the treatment of FGIDs (Table 6).

Commonly used FMHs that exert their FGID-treating effects through flavonoids such as tsaoko fruit. Poria polysaccharides have been shown to improve the gastrointestinal mucosa and barrier, thereby acting on IBS, FD. Astragalus root polysaccharides

Table 4 Chinese herbal compound prescriptions for the treatment of FGIDs

Illness	Formula name	Components	Interventions	Study design	Results	Ref.
FC	Shouhui Tongbian Capsules	Fleece-flower root, aloes, cassia seed, ginseng, lycium fruit, donkey-hide glue, citrus aurantium(food), white atractylodes rhizome (5/8, 62.5%)	TCM group vs control group	14 RCTs	Significantly improved the total effective rate and curative effect, clinical symptom score, gastrointestinal peptide index and reduced adverse reactions and recurrence rate. The efficacy in FD patients was superior to that of prokinetic drugs, significantly improved the gastrogram, promoted gastrointestinal motility and gastric emptying, decreased gastric sensitivity, regulated gastrointestinal hormones, and significantly improved symptoms	[26]
FD	Xiangsha Liujunzi Decoction	Ginseng, white atractylodes rhizome, poria, licorice root, Pinellia tuber, aged tangerine peel, ginger rhizome, Chinese date, aucklandia, amomum fruit (7/10, 70%)	TCM group vs West medicine group	15 RCTs	Significantly better than the control group in terms of total effective rate and relief of clinical symptoms in the treatment of FD	[27]
FD	Jianpi Yiqi Decoction	Codonopsis root, white atractylodes rhizome, poria, licorice root, aged tangerine peel, Pinellia tuber (4/6, 66.67%)	TCM group vs control group	15 RCTs	More efficient than Western medicine, combination therapy more efficacious than Western medicine group in boosting motilin secretion and in aspect of the SCL-90-R	[28]
FD	Banxia Xiexin Decoction	Pinellia tuber, scutellaria, ginger rhizome, ginseng, licorice root, coptis rhizome, Chinese date (4/7, 57.14%)	TCM group or combined with West medicine group	57 RCTs	Formula was associated with significant improvements in cure rate, diarrhea severity score, abdominal pain severity score, and abdominal distention severity score	[29]
IBS	Shenling Baizhu Powder	Ginseng, poria, white atractylodes rhizome, dioscorea rhizome, lablab, lotus seed, coix seed, amomum fruit, platycodon root, licorice root (9/10, 90%)	TCM group vs West medicine group	13 RCTs	Improved overall symptoms and abdominal pain in IBS patients ($P < 0.001$)	[30]
IBS	Mint oil	Mint (1/1, 100%)	TCM group vs West medicine group	9 RCTs	Significantly improved overall clinical effectiveness, significantly improved scores for the stool trait, frequency of defecation, and abdominal pain	[31]
IBS	Sijunzi Decoction	Ginseng, poria, white atractylodes rhizome, licorice root (3/4, 75%)	TCM group or combined with west medicine vs West medicine group	14 RCTs	Overall clinical outcome was significantly improved, scores for bloating, frequency of bowel movements and faecal character were significantly improved	[32]
IBS	Xiaoyao Powder	Bupleurum, pubescent angelica root, white peony root, white atractylodes rhizome, poria, licorice root, mint, fresh ginger rhizome (5/8, 62.5%)	TCM group vs West medicine group	14 RCTs		[33]

Table 5 Chinese herbal extracts for the treatment of FGIDs

Functional herbs	Evaluation model	Group and administration	Result	Mechanisms	Ref.
Fresh ginger rhizome podwer	11 patients with FD	1.2g ginger capsule daily vs placebo group (starch capsule), tested on the same day	Gastric emptying was more rapid after ginger than placebo [T50: 12.3 (8.5-17.0) min vs 16.1 (8.3-22.6) min, $P \leq 0.05$], more antral contractions, $P = 0.06$	Regulate gastric motility	[35]
Mint alcohol extract	50 patients with FD	Placebo group, administer group (330 mg peppermint extract) 3 times daily for 2 months	Significantly reduced total dyspepsia score (decreased 6.9 score, $P < 0.001$) and gastroparesis, epigastric flatulence, epigastric cachexia, belching scores as measured by the Dyspepsia Index, significantly improved quality of life as measured by the SF-36 questionnaire (decreased 7.84 score, $P < 0.001$), and significantly reduced <i>Helicobacter pylori</i> infection as measured by the H. urease test, $P < 0.001$	Regulate gastric motility, regulate intestinal flora	[36]
Amomum fruit extract	88 patients with FD of the spleen and stomach	Western medicine group, treatment group extract (5 ml/dose, equivalent to 6 g of amomum) 3 times a day for one month	Significantly improved the total effective rate (95.45% vs control group 77.27%, $P < 0.05$), the observation group had lower TCM scores 9.65 ± 1.08 and higher quality of life scores 86.89 ± 2.47 than those of the control group, $P < 0.05$	/	[37]
Fresh ginger rhizome + artichoke	126 patients with FD	Supplement group, placebo group, 2 capsules/day, 28-day regimen	Significantly improved MCA severity scale, according to the latent curve models (LCMs) step, the intercept was significantly higher in patients treated with supplementation than in the placebo group ($\alpha S\text{-ap} = +0.848$ units, $P < 0.001$). Enhanced therapeutic effect: significant reduction in the intensity of dyspepsia (treated group 63.1% vs 24.6% placebo), significant improvement in nausea, epigastric fullness, epigastric pain and bloating	/	[38]
Aqueous extract of <i>Phyllanthus emblica</i> L.	FD mice	Normal group, model group, emblica group (150, 300 mg/kg) administered for 3 weeks	Improved gastrointestinal motility alongside, GE and SIT rate, $P < 0.05$, increased the level of serum gastrointestinal hormones such as motilin (MTL) and gastrin (GAS), decreased the vasoactive intestinal peptide (VIP) level, $P < 0.05$, regulated the microbiome structure and restore homeostasis by elevating useful bacterial abundance	Regulate gastrointestinal motility, regulate intestinal flora	[39]
Taraxacum officinale alcohol extract	FC Rats	Positive control group, CSP group, control group, experimental group (0.2 ml of dandelion alcohol extract, ethyl acetate fraction, n-butanol fraction and aqueous fraction at a concentration of 100 mg/(kg·bw), s.c.) administered for 20 minutes	Promoted gastrointestinal peristalsis, gastric emptying (GE) significantly increased to $86 \pm 6.5\%$, $P < 0.05$, enhanced contraction of round smooth muscle of the gastric sinus, $P < 0.05$, and the combination of propranolol and n-butanol fraction (BF) showed an additive effect, accelerating GE from $85.8 \pm 5.1\%$ to $91.7 \pm 4.5\%$, $P < 0.05$	Regulate gastrointestinal motility, cholinergic pathway	[40]
Pubescent angelica root	Tissue samples and human epithelial cell line T84	Normal group, STW5 group, angelica group (89.5 $\mu\text{g}/\text{ml}$)	Evoked a pro-secretory action in human tissues, $P = 0.06$, the effects involve activation of cAMP- and Ca^{2+} -activated Cl^- channels	cAMP and calcium dependent chloride channels	[41]
Desert-living cistanche	FC rats	Cistanche group (0.156 g/100 g, 10 ml/kg), blocker group, control group, model group, administered for 20 days	Improved the integrity and continuity of the epithelial cells and regular arrangement of the glands, improved defecation in rats with constipation, $P < 0.05$, significantly increased C-kit protein expression, $P < 0.05$, inhibited expression of AQP3 and promoted expression of Cx43, $P < 0.05$	SCF/C-Kit pathway, regulate intestinal movement	[42]
Hawthorn fruit	FC mice	Control group, model control group, positive control group and 2 hawthorn fruit dietary fibre dose groups (1, 2 g/(kg·bw)), administered for 45 days	Significantly upregulated AQP3 and AQP8 by 52.67% and 164.54%, downregulated AQP9 protein expression by 45.88%, increased the levels of excitatory hormones such as MTL, GAS, and SP in the gastrointestinal tract, and reduced the levels of inhibitory hormones such as SS, NO, and MDA ($P < 0.01$ or $P < 0.05$), reduced the levels of inflammatory factors such as IL-6 and IL-1 β ($P < 0.01$), increased the content of various short-chain fatty acids ($P < 0.05$), alleviated intestinal inflammation, promoted the growth of probiotics such as <i>Bacteroides</i> , inhibited the growth of harmful bacteria such as <i>Lactobacillus</i> , and altered the diversity of gut microbiota	Regulate intestinal flora, regulate SCFAs levels, anti-inflammatory, regulate immune response, regulate intestinal movement, enhance intestinal barrier	[43]
Cassia seed + fennel	FC mice	CF (100, 300, 500 mg/kg), lop group, control group, positive control group, administered for 4 weeks	Dramatically improved the stool parameters, such as colonic peristalsis from the intestinal transit length and ratio (decreased 11.3% and 13.4%, respectively), enhanced the thicknesses of mucosa and muscular layers of the colon in constipated rats, $P < 0.05$, the mRNAs and proteins expression of muscarinic acetylcholine receptors (mAChR) M2 and M3 and their downstream signaling were preserved	Regulate intestinal movement, enhance intestinal barrier	[44]

(Continued)

Functional herbs	Evaluation model	Group and administration	Result	Mechanisms	Ref.
Aloes	68 IBS patients	Aloe vera extracts (250 mg AVH200®) for 4 weeks	Significantly relieved IBS symptoms (314 ± 8 vs 257 ± 107 , $P = 0.003$), pain severity ($P = 0.011$), pain frequency ($P = 0.010$) and bloating ($P = 0.003$) on the IBS-SSS subscales were significantly improved	Relieve pain	[45]
Psoralea fruit + nutmeg	IBS rats	Normal group, model group, psoralen-nutmeg alcohol-water double extraction group, alcohol extraction group, water extraction group (10 g/kg, 6 times as much as 18 g/day of raw drug in human), positive drug group, administered for 14 days	Significantly elevated pressure thresholds for abdominal lifting and dorsal arching ($P < 0.05$ to $P < 0.01$), improved visceral hypersensitivity, and reduced colonic motility in rats, decreased the levels of CRF and RFRI	Neuroendocrine regulation	[46]
Cinnamon bark	IBS-D rats	Cinnamon bark group (30, 90, 270 mg/(kg·day)), ramosetron group, control group, model group. 14 days of administration	Reduced defecation frequency and visceral hyperalgesia, improved visceral sensitivity in TNBS rats, the efficacy was comparable to the positive drug ($P < 0.05$), significantly inhibited Tph1 transcription activity ($P < 0.005$) and the gene and protein levels of the colonic 5-HT synthetase ($P < 0.05$)	5-HT metabolism, alleviate visceral allergic reactions	[47]

Table 6 Chinese herbal component for the treatment of FGIDs

Functional ingredients	Evaluation model	Group and administration	Occurring mechanism or effect	Mechanisms	Reference
Curcumin	132 FD patients	Curcumin (500 mg per capsule, four times daily after meals), omeprazole, and placebo groups, 4 weeks of administration	Curcuma longa Linn could improve dyspeptic symptoms, decreased the SODA score, $P < 0.01$, improved quality of life and improved EQ-5D index (0.12 ± 0.13 vs 0.07 ± 0.05 , $P = 0.053$), EQ-VAS (17.2 ± 10.6 vs 10.5 ± 8.3 , $P < 0.003$)	Relieve pain	[50]
Poria cocos (triterpenoid, PCT, water-soluble polysaccharide, PCWP)	FD rats	Control, model, BZYQP (Buzhongyiqi Pill), PCD, PCT (55 mg/kg, equal to crude drug 7.5 g/kg), PCWP (67 mg/kg, equal to crude drug 7.5 g/kg) and PCAP (558 mg/kg, equal to crude drug 1.0 g/kg) group, once daily for 2 weeks	Alleviated the symptoms of FD, increased serum d-xylose, ACh, ALB and TP levels ($P < 0.05$, or $P < 0.01$), increased GAS, MTL, VIP, SP levels, decreased CCKAR, CGRP, 5-HT levels ($P < 0.05$ or $P < 0.01$), promoted the repair of gastrointestinal mucosa, regulated IL-1 β , IL-2, IL-4, IL-17, TGF- β 1, GATA3, Foxp3 levels, decreased the expression of p-c-Jun, TRAF6, ROR- γ t ($P < 0.05$ or $P < 0.01$)	Promote the repair of gastrointestinal mucosa, regulate immune response, regulate Gut-brain axis	[51]
Flavonoids in tsaoko fruit	30 constipated rats	Model group, control group, positive control group, LAE group (500, 750, 900 mg/(kg·bw) ATAE), same day defecation test	Alleviated Loperamide-Induced STC Symptoms, restored gut microbial dysbiosis, increased the abundance of Lactobacillus and Bacillus and reduced the dominant commensals, increased the serum serotonin (5-HT) content and mRNA expression of 5-hydroxytryptamine receptor 2A (5-HT _{2A}), phospholipase A ₂ , and cyclooxygenase-2, $P < 0.05$ or $P < 0.01$, increased transient receptor potential A1 (TRPA1) and MLC3, reduced the serum level of iNOS, positively correlated with metabolites enriched in the serotonergic synapse pathway, including PGJ2, TXB2, 14,15-DiHETE and PGC2	Regulate intestinal flora, regulate intestinal movement, regulate SCFAs levels	[52]
Astragalus polysaccharide	Elderly constipated rats	Negative control (NC) group, aged constipated rat model group (MS), PC group (1.875 mg/kg) and APS group (200 mg/kg). 8 weeks of administration	Significantly improved the defecation of mice, enhanced the gastrointestinal propulsion rate, $P < 0.01$, improved SOD, GSH-Px and CAT levels ($P < 0.01$, $P < 0.05$, $P < 0.05$), altered the gut microbiota structure, recovered the levels of lactobacillus, saccharopolyspora, anaerofustis, rhodobacter and aquabacterium, significantly regulated five metabolites involved in the glycolysis/gluconeogenesis and pyruvate pathways, including isoleucine, propionate, acetate, butyrate and acetone, $P < 0.05$	Anti-oxidative stress, regulate intestinal flora, regulate SCFAs levels	[53]
Turmeric rhizome + fennel extract	211 IBS patients	Enterofytol®, (turmeric 42 mg + 25 mg fennel essential oil), administered for 60 days	A significant reduction in the IBS severity index (from $29 \pm 23\%$ to $17 \pm 35\%$, $P < 0.0001$), the number of different pain locations dropped from 2.2 ± 1.5 at baseline to 1.2 ± 1.1 , $P < 0.0001$, QoL improved from baseline, reaching a mean increment of $31 \pm 40\%$, the maximum number of weekly evacuations decreased from 20 ± 14 to 14 ± 9 ($P < 0.0001$)	Relieve pain	[54]

(Continued)

Functional ingredients	Evaluation model	Group and administration	Occurring mechanism or effect	Mechanisms	Reference
Ginseng total saponins	IBS rats	Control group, model group, ginseng GTS, PD or PT group (GTS 0.1 to 1000 mg/kg, PD and PT 100 mg/kg), same day defecation test	PD, PT significantly and dose-dependently inhibited CRD-acetic acid-induced abdominal contractions in the dose range of 0.1–300 mg/kg, EC_{50} was 5.5 ± 4.7 mg/kg, thereby attenuating visceral anaphylactic reactions, with the anti-anaphylactic effect peaking at 20 min after administration and remaining significant for the next 240 min Increased food intake and fecal water content, increased mucosal and muscle thickness in different intestinal segments. Significantly improved the physiological status of mouse intestine, up-regulated the expression of intestinal Occludin and ZO-1 ($P < 0.05$), down-regulated the levels of serum endotoxin, DAO, D-lactic acid and intestinal MPO ($P < 0.05$). Up-regulated the expression of MUC2, β -defensin and SIgA in intestinal tissues, increased the expression of IL-2, IL-4, IL-6, IL-10, TGF- β and IFN- γ to regulate the immune barrier ($P < 0.05$ or $P < 0.01$), increased the level of short-chain fatty acids in the small intestinal contents ($P < 0.05$)	Alleviate visceral allergic reactions, inhibit 5-HT3A receptors	[55]
Poria cocos polysaccharide	C57BL/6 mice	Control group: distilled water, Poria Cocos Polysaccharide (PCP) in low, medium and high dose groups (75 mg/kg, 150 mg/kg and 300 mg/kg) in a gavage volume of 0.2 mL/10 g administered for 7 days		Enhance intestinal barrier, anti-oxidative stress, regulate immune response, regulate intestinal flora, regulate SCFAs levels	[56]

regulated five metabolites involved in the FC pathways. Furthermore, saponins such as ginseng saponins and poria saponins also show some therapeutic potential. Polyphenols in curcumin^[49] have long been considered to have excellent antioxidant and anti-inflammatory effects, which play an essential role in maintaining a healthy gastrointestinal tract.

4.4 Pathophysiological Mechanisms of FGIDs

FGIDs were once considered purely psychosomatic, with no identifiable abnormalities in the gastrointestinal tract. However, as understanding of their pathophysiology has advanced, FGIDs are now recognized as complex, heterogeneous, and multifactorial conditions. In addition to environmental factors, dietary influences, and genetic predisposition, both CNS sensory processing (e.g., psychological disorders, stress, depression, anxiety) and alterations in the peripheral gastrointestinal system (e.g., low-grade intestinal inflammation, infections, microbiota imbalances, increased intestinal permeability, abnormal gastrointestinal motility, disordered bile salt metabolism, visceral hypersensitivity, and immune activation) are thought to play a role in their development^[1,57,58].

These mechanisms interact dynamically rather than functioning in isolation. For example, the degranulation of mast cells and eosinophils releases inflammatory mediators that can compromise the intestinal barrier, stimulate, and damage enteric nerve fibers, leading to visceral hypersensitivity and motility disturbances, which manifest as gastrointestinal symptoms^[1]. Alterations in the intestinal microbiota may affect intestinal permeability and immune activation, further influencing the state of inflammation and visceral sensitivity^[59]. Drugs currently proposed to target these pathophysiological mechanisms are shown in Fig. 2B^[6].

5 Health care products to alleviate FGIDs

5.1 Claims of health care products

The Health Function Catalogue of Permitted Health Food Claims Non-Nutrient Supplements (2023), jointly issued by the State Administration for Market Regulation, the National Health

Commission of the People's Republic of China, and the National Administration of Traditional Medicine, standardized the management of the claims of health care products. Among them, four claims changed are the gastrointestinal tract (Table 7). Since FGIDs also involve digestion, intestinal flora, gastric mucosa, and laxative issues, this section includes not only FGIDs but also other gastrointestinal digestive diseases.

Using the Yaozhi website (<https://db.yaozh.com/>) for data retrieval on health care products by inputting “stomach”, “intestine”, and “digestion”, which cover the eight claims of the initial and current ones, 487, 558, and 110 entries were yielded for the three keywords, respectively. After deduplication, 603 unique entries were obtained in total.

Among these 603 products, there is a significant variation in the proportions of products with different functions (Fig. 3A). The largest proportion of products, 329 in total accounting 54.6% of all the products, is able to moisten dryness and promote bowel movements. 134 products can help regulate the intestinal flora, reflecting a strong consumer demand for improving intestinal function and addressing constipation issues. There were 100 products that aid digestion and 85 that protect the gastric mucosa, respectively. Meanwhile, more than 200 health care products with gastrointestinal tract improvement efficacy are not limited to a single function but are also recognized for helping to regulate blood glucose, blood pressure, blood lipids, anti-aging, and weight loss properties. This indicates the close relationship between gastrointestinal diseases and a wide range of other health issues, and that products aimed at improving gastrointestinal function also have multiple benefits.

In terms of dosage form selection (Fig. 3B), products aimed at improving gastrointestinal issues are distributed as follows: capsules are the most cases with 207 products, followed by 103 oral liquids. Additionally, the number of products in the form of tablets, powders, and granules are 64, 50, and 69, respectively. Among them, capsules and oral liquids, as the main dosage forms, have a higher frequency of occurrence, indicating a preference by consumers and manufacturers for these forms in gastrointestinal health care products over other types.

In the market composition of gastrointestinal health care products, companies are notably dispersed, with no leading

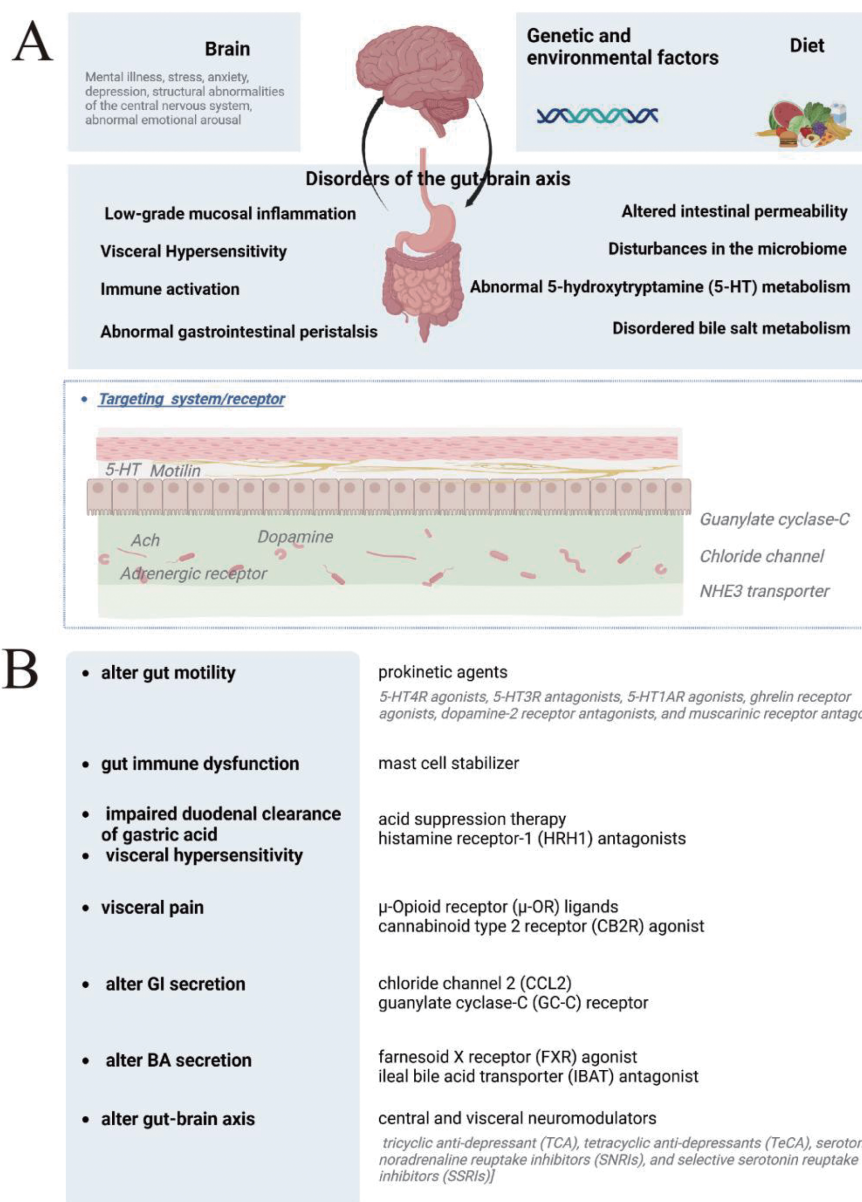


Figure 2 (A) Pathophysiological mechanisms in disorders of gut-brain interaction, (B) Currently available pharmacological agents based on pathophysiological mechanisms.

Table 7 Gastrointestinal-related claims for health care food

Number	Current health function claims	Former health function claims
1	Help regulate intestinal flora	Improve gastrointestinal function (regulate intestinal flora), regulate intestinal flora
2	Help in digestion	Improve the gastrointestinal function (promote digestion), promote digestion
3	Help with laxative	Improve the gastrointestinal function (laxative), laxative
4	Auxiliary protection of gastric mucosa	Improve the gastrointestinal function (auxiliary protection against gastric mucous membrane damage), auxiliary protection against gastric mucous membrane damage)

company dominating a large market share (Fig. 3C). Among all companies producing gastrointestinal health care products, Guangdong Taiyangshen Group Co., Ltd. has the highest number of products, with 6 in total. Following closely are Beijing Yushengtang Health Products Co., Ltd., Guangdong Yibo Health Products Co., Ltd., and Shanghai Gaobote Biotechnology Health Products Co., Ltd., each with five distinct gastrointestinal health care products. Other companies producing similar products have relatively fewer products. This indicates that the current gastrointestinal health care products market is highly competitive,

with no specific enterprise or brand holding an absolute market advantage, which also provides market space for new entrants.

By applying Excel's COUNTIF function, this review conducted a frequency analysis of the formula ingredients in a series of health care products aimed at treating gastrointestinal diseases. The results of this analysis are seven commonly used FMH plants, which are hawthorn fruit, poria, cassia seed, radish seed, aged tangerine peel, hemp seed, and aloes. On the other hand, utilizing the Apriori algorithm in R, we have carried out an in-depth correlation analysis of the products by setting the antecedent

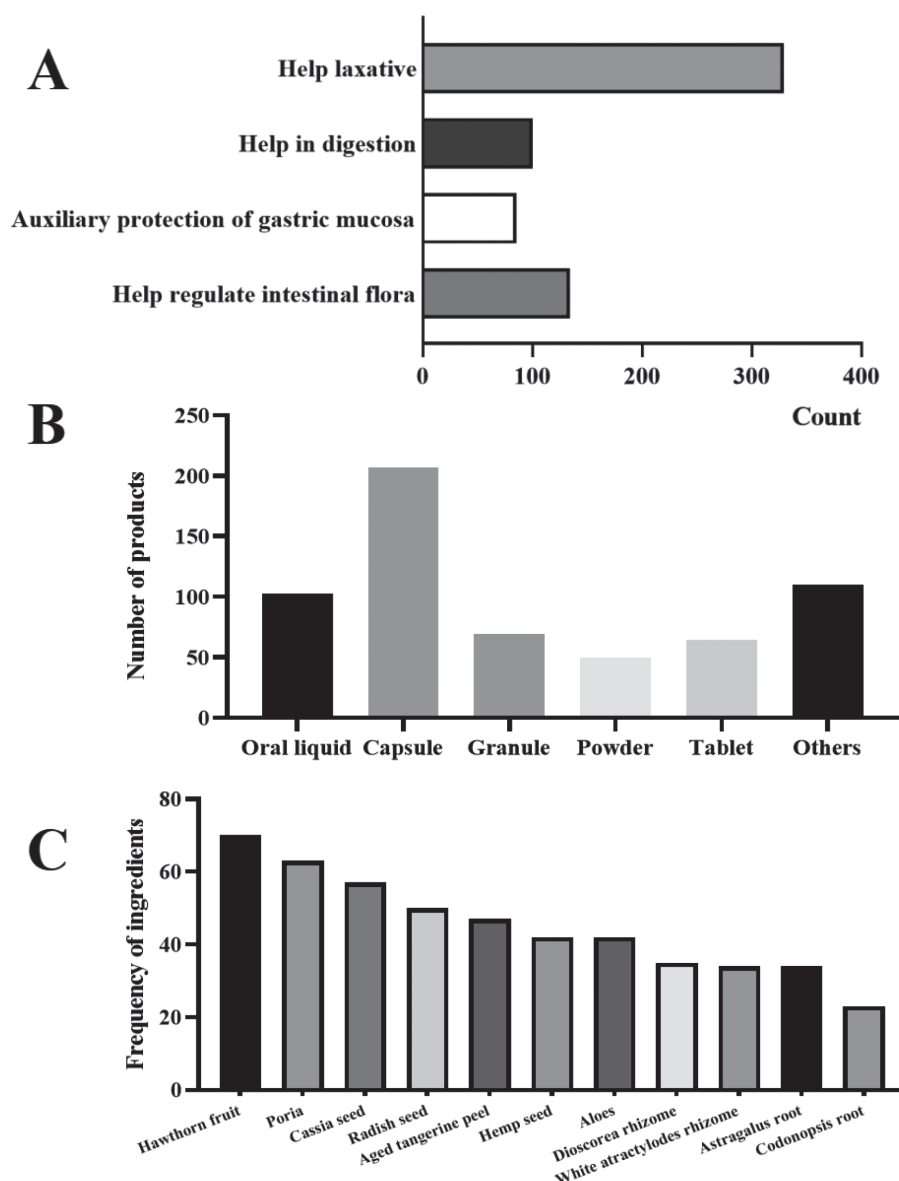


Figure 3 Analysis of health care products used to improve the conditions of gastrointestinal disorders. (A) Variety of claims, (B) Dosage form of the products, (C) Frequency of FMH materials in the products (frequency ≥ 20).

support threshold to $\geq 4.5\%$ and the rule confidence to $\geq 50\%$, which finally resulted in the discovery of 13 combinations that appeared at least 20 times. Among them, 10 combinations consist of two FMH herbs, and three combinations contain three FMH herbs. These pairs were ranked from high to low according to the degree of support as shown in Table 8. The most frequent combinations are Barley Sprout-Hawthorn Fruit, {Poria} $\Rightarrow$ {Hawthorn Fruit}, {Radish seed} $\Rightarrow$ {Hawthorn Fruit}. The pairs with the highest level of confidence were {Aged Tangerine Peel, Barley Sprout} $\Rightarrow$ {Hawthorn Fruit}, {Poria, Barley Sprout} $\Rightarrow$ {Hawthorn Fruit}, {Radish Seed, Barley Sprout} $\Rightarrow$ {Hawthorn Fruit}.

5.2 Safety and adverse reactions

After years of clinical validation, extensive safety research, and certification from professional agencies such as the State Administration for Market Regulation and the National Health Commission of the People's Republic of China, the high safety nature of FMH materials is a widely recognized fact. As part of the daily diet, FMH materials can be used for long-term disease

prevention and treatment.

However, it should be kept in mind that improper use of certain FMH materials may also introduce direct toxic and side effects. These side effects may arise from the toxic ingredients contained in the materials themselves or from improper processing and preparation methods. Therefore, if these materials are to be used as long-term medications, the application context needs to be considered carefully.

Origins of food and medicinal herbs (FMH) are important, as there may be significant differences in terms of bioactive and/or adverse components between wild-sourced and cultivated herbs. Environmental factors, such as heavy metal contamination, can pose risks in wild herbs, while long-term passive exposure to pesticides in cultivated herbs may result in cumulative health hazards. These risks include neurodevelopmental and endocrine disorders, as well as teratogenic, mutagenic, and carcinogenic effects^[60].

Determining the safe dosage of FMH materials is essential to ensure their safety. Excessive consumption of FMH materials generally considered safe can pose health risks. According to

Table 8 Apriori algorithm-based association rules of herbs

Lhs		Rhs	Support	Confidence	Coverage	Lift	Count
{Barley Sprout}	=>	{Hawthorn Fruit}	0.0901	0.7049	0.1279	4.6701	43
{Poria}	=>	{Hawthorn Fruit}	0.0734	0.5469	0.1342	3.6230	35
{Radish Seed}	=>	{Hawthorn Fruit}	0.0629	0.5660	0.1111	3.7500	30
{Aged Tangerine Peel}	=>	{Hawthorn Fruit}	0.0587	0.5957	0.0985	3.9468	28
{Radish Seed}	=>	{Barley Sprout}	0.0587	0.5283	0.1111	4.1311	28
{Barley Sprout}	=>	{Poria}	0.0587	0.4590	0.1279	3.4211	28
{Gizzard Lining}	=>	{Barley Sprout}	0.0545	0.7222	0.0755	5.6475	26
{Aged Tangerine Peel}	=>	{Barley Sprout}	0.0503	0.5106	0.0985	3.9930	24
{Aged Tangerine Peel}	=>	{Poria}	0.0503	0.5106	0.0985	3.8059	24
{Poria, Barley Sprout}	=>	{Hawthorn Fruit}	0.0482	0.8214	0.0587	5.4420	23
{Dioscorea Rhizome}	=>	{Hawthorn Fruit}	0.0482	0.6571	0.0734	4.3536	23
{Aged Tangerine Peel, Barley Sprout}	=>	{Hawthorn Fruit}	0.0461	0.9167	0.0503	6.0729	22
{Radish Seed, Barley Sprout}	=>	{Hawthorn Fruit}	0.0461	0.7857	0.0587	5.2054	22

Carstairs SD's^[61] retrospective review of a 10-year toxicological database, patients who abused nutmeg were more likely to experience tachycardia and agitation compared to those who were unintentionally exposed to nutmeg ($P < 0.05$). Large doses (25–28 g) of nutmeg, whether for edible or medicinal use, were associated with toxic side effects such as tachycardia, nausea, vomiting, agitation, and hallucinations.

Chinese medicinal properties (CMP) are a crucial component of the basic theory of TCM, serving as the foundation for the correct use of herbs based on their pharmacognosy and applicability to different populations. Saffron, for example, is a TCM used for treating mental illness, atherosclerosis, hypertension, gastric ulcer, and other diseases. However, because saffron activates blood circulation and removes blood stasis, it can potentially damage foetal qi. Ginseng is suitable for patients with asthenia syndrome, but excessive use might cause “Shanghuo” in people with fire-heat syndrome or excess qi, disturbing the qi and xue according to TCM theory^[62]. Similarly, lycium fruit and longan aril, which are used for medicinal and dietary purposes, are also reported to cause “Shanghuo” symptoms such as dry mouth and throat, epistaxis, sore throat, and swelling and bleeding of the gums^[63,64].

6 Conclusions and prospects

FGIDs are a group of conditions characterized by the absence of organic lesions, and they are now increasingly recognized as complex, heterogeneous, and multifactorial. Along with genetic and psychological factors, abnormalities in the brain-gut axis have been implicated in their pathogenesis. Among FGIDs, IBS, FD, and FC are the most common disorders.

The traditional concept of FMH materials can regulate body functions, prevent and treat diseases, and provide a milder and more easily accepted treatment option for FGIDs. FMH herbs, usually derived from daily consumed foods, typically show minimal gastrointestinal irritation and low toxicity, making them safe for long-term use. Their pharmacological activities provide them with preventive and therapeutic potential, particularly in managing chronic diseases. Many of the FMH plants are rich in nutrients such as proteins and vitamins, which are beneficial to the human body. They can also be consumed directly through food or foodstuffs, or they can be extracted and used flexibly to produce medicines or healthcare products^[65].

With the continuous development of modern scientific

research, an increasing number of FMH materials have therapeutic effects on FGIDs. For example, herbal formulas such as Xiangsha Liujunzi Decoction, Jianpi Yiqi Decoction, Banxia Xiexin Decoction, and TCM preparations including fresh ginger rhizome, mint, amomum fruit, emblic leaf-flower fruit, Poria cocos, as well as bioactive ingredients such as curcumin have demonstrated clear therapeutic effects on functional dyspepsia. Additionally, Shouhui Tongbian Capsules, dandelion alcohol extract, Pubescent angelica root, desert-living cistanche, hawthorn fruit, cassia seed in conjunction with fennel, flavonoids from tsaoko fruit, and astragalus polysaccharides showed good efficacy in treating FC. Meanwhile, Shenling Baizhu Powder, Sijunzi Decoction, Xiaoyao Powder, mint oil, Psoralea fruit with desert-living cistanche, cinnamon bark, aloes, turmeric rhizome with fennel, ginseng, etc. could effectively alleviate the pathological symptoms of IBS. In current clinical research, while numerous studies have provided findings on established herbal formulas, more in-depth discussion and data are still needed to support the study of individual herbs and multi-herb formulations. As public awareness of the potential therapeutic effects of medicinal and food herbs (FMH) grows, there is an urgent need for more advanced clinical trials and mechanistic studies. This would provide a stronger scientific foundation for product development and ensure greater reliability.

With the changing needs of disease diagnosis and treatment, a multitude of products targeting different disease needs are emerging in the market. Notably, there is a rich variety of healthcare products aimed at moistening dryness and promoting bowel movements, primarily in the form of capsules and oral liquids to meet the needs of various application scenarios. However, the market is still relatively fragmented, and competition between companies is not yet intense, providing numerous opportunities for the development of new products.

In terms of the combination of herbal materials, pairs like “Barley sprout-Hawthorn fruit”, “Poria-Hawthorn fruit”, “Radish seed-Hawthorn fruit” are quite common, indicating the advantages of these combinations in treating related diseases. The efficacy of these combinations can be further validated through clinical trials and long-term follow-up studies.

There is growing public interest in the concept of active health, with an emphasis on prevention over treatment and a focus on scientifically-backed, effective health products. As a result, the market demands a wider range of health products, including

functional foods, dietary supplements, and Food for Special Medical Purposes (FSMP), to meet the increasing demand. Researchers can explore niche product formulations and develop various product formats to diversify market offerings and establish differentiated benchmarks. Considering the multiple organs involved in functional gastrointestinal diseases, their strong interactions, and the diversity of these diseases, treatment strategies need to be further explored and studied from multiple perspectives. The investigation of pharmacological mechanisms, such as promoting intestinal motility and regulating bile acid secretion, remains an important area of focus.

FMH materials offer advantages in various areas, including research background, safety, and regulatory compliance, which can enable companies to bring their products to market more efficiently. In addition, to exert the effects to the largest extent, the use of FMH as a therapeutic tool needs to be accompanied by a complete formula. However, on the way to developing a product, the completeness and dosage of the formula are usually restricted by laws. Since commonly used herbs such as pinellia tuber and white atractylodes rhizome are not FMH materials in some validated formulas, looking for alternatives that can be used to replace those non-FMH ones and/or recruiting them into the FMH category are two ways to assist the application of FMH to a further step. Besides, existing formulation concepts can be used to recompose new combinations by employing FMH materials. Of course, this requires the joint efforts of policymakers, researchers, medical practitioners, and industry stakeholders.

Overall, there remain many unexplored areas in therapeutic approaches to functional gastrointestinal disorders (FGIDs), particularly those involving food and medicinal herbs (FMH) materials. Future research and innovation are needed to establish a more reliable scientific foundation for product development and clinical treatment in this field.

Conflicts of interest

The authors declare that there are no conflicts of interest in this work.

Acknowledgements

This work was supported by the Zhejiang Provincial Natural Science Foundation of China (No. LQ24H280012), the National Natural Science Foundation of China (No. 82304755), the Traditional Chinese Medicine Science and Technology Project of Zhejiang Province (No. 2024ZL343) and the Fundamental Research Funds for Central Universities (No. 226-2024-00001).

References

- [1] Black, C. J., Drossman, D. A., Talley, N. J., et al. Functional gastrointestinal disorders: advances in understanding and management. *The Lancet*, **2020**, 396: 1664–1674. [https://doi.org/10.1016/S0140-6736\(20\)32115-2](https://doi.org/10.1016/S0140-6736(20)32115-2)
- [2] Sperber, A. D., Bangdiwala, S. I., Drossman, D. A., et al. Worldwide Prevalence and Burden of Functional Gastrointestinal Disorders, Results of Rome Foundation Global Study. *Gastroenterology*, **2021**, 160: 99–114.e113. <https://doi.org/10.1053/j.gastro.2020.04.014>
- [3] Ghoshal, U. C. Marshall and Warren lecture 2019: A paradigm shift in pathophysiological basis of irritable bowel syndrome and its implication on treatment. *Journal of Gastroenterology and Hepatology*, **2020**, 35: 712–721. <https://doi.org/10.1111/jgh.15032>
- [4] Ghoshal, U. C., Singh, R. Pathogenesis of irritable bowel syndrome: is it really in the gene? *Journal of Neurogastroenterology and Motility*, **2014**, 20: 284–286. <https://doi.org/10.5056/jnm14071>
- [5] Singh, R., Wei, L., Ghoshal, U. C. Micro-organic basis of functional gastrointestinal (GI) disorders: Role of microRNAs in GI pacemaking cells. *Indian Journal of Gastroenterology*, **2021**, 40: 102–110. <https://doi.org/10.1007/s12664-021-01159-7>
- [6] Singh, R., Zogg, H., Ghoshal, U. C., et al. Current Treatment Options and Therapeutic Insights for Gastrointestinal Dysmotility and Functional Gastrointestinal Disorders. *Frontiers in Pharmacology*, **2022**, 13: 808195. <https://doi.org/10.3389/fphar.2022.808195>
- [7] Chuah, K. H., Beh, K. H., Mahamad Rappek, N. A., et al. The epidemiology and quality of life of functional gastrointestinal disorders according to Rome III vs Rome IV criteria: A cross-sectional study in primary care. *Journal of Digestive Diseases*, **2021**, 22: 159–166. <https://doi.org/10.1111/1751-2980.12975>
- [8] Clevers, E., Whitehead, W. E., Palsson, O. S., et al. Factor Analysis Defines Distinct Upper and Lower Gastrointestinal Symptom Groups Compatible with Rome IV Criteria in a Population-based Study. *Clinical Gastroenterology and Hepatology*, **2018**, 16: 1252–1259.e1255. <https://doi.org/10.1016/j.cgh.2018.02.042>
- [9] Khalil, T. A., Filmban, D. M., Sinnah, H. N. M., et al. Knowledge, Attitude, and Practices Regarding the Rome IV Criteria for the Diagnosis of Irritable Bowel Syndrome Among Primary Healthcare Physicians in Saudi Arabia. *Cureus*, **2023**, 15: e49460. <https://doi.org/10.7759/cureus.49460>
- [10] Schmulson, M. J., Drossman, D. A. What is New in Rome IV. *Journal of Neurogastroenterology and Motility*, **2017**, 23: 151–163. <https://doi.org/10.5056/jnm16214>
- [11] Lacy, B. E., Patel, N. K. Rome Criteria and a Diagnostic Approach to Irritable Bowel Syndrome. *Journal of Clinical Medicine*, **2017**, 6. <https://doi.org/10.3390/jcm6110099>
- [12] Zeng, Y., Yang, J., Chen, J., et al. Actional Mechanisms of Active Ingredients in Functional Food Adlay for Human Health. *Molecules*, **2022**, 27. <https://doi.org/10.3390/molecules27154808>
- [13] Ma, A., Zou, F., Zhang, R., et al. The effects and underlying mechanisms of medicine and food homologous flowers on the prevention and treatment of related diseases. *Journal of Food Biochemistry*, **2022**, 46: e14430. <https://doi.org/10.1111/jfbc.14430>
- [14] Zhong, H., Tang, Z., Li, Y., et al. The evolution and significance of medicine and food homology. *Acupuncture and Herbal Medicine*, **2024**, 4: 19–35. <https://doi.org/10.1097/HM9.0000000000000104>
- [15] Hao, Y. F., Jiang, J. G. Origin and Evolution of China Pharmacopoeia and Its Implication for Traditional Medicines. *Mini-Reviews in Medicinal Chemistry*, **2015**, 15: 595–603. <https://doi.org/10.2174/1389557515666150415150803>
- [16] Li, Z., Xu, C. The fundamental theory of traditional Chinese medicine and the consideration in its research strategy. *Frontiers of Medicine*, **2011**, 5: 208–211. <https://doi.org/10.1007/s11684-011-0126-x>
- [17] Hao, Y., Liu, H., Yue, S., et al. Introducing traditional Chinese nursing: a review of concepts, theories and practices. *International Nursing Review*, **2011**, 58: 319–327. <https://doi.org/10.1111/j.1466-7657.2011.00918.x>
- [18] WHO international standard terminologies on traditional Chinese medicine. World Health Organization. 2022.
- [19] Meng, M., Wang, S., Zhang, S. Interpretation of the experts consensus on traditional Chinese medicine diagnosis and treatment of functional dyspepsia (2023). *Chinese Journal of Integrated Traditional and Western Medicine on Digestion*, **2024**, 32: 564–567,574. <https://doi.org/10.3969/j.issn.1671-038X.2024.07.04>
- [20] Zhang, S., Wei, W., Yang, J. Expert consensus on traditional Chinese medicine diagnosis and treatment of irritable bowel syndrome (2017). *Journal of Traditional Chinese Medicine*, **2017**, 58: 1614–1620. <https://doi.org/10.13288/j.11-2166/r.2017.18.024>
- [21] Li, J., Chen, J., Ke, X. Consensus opinions on the diagnosis and treatment of functional constipation by integrated traditional Chinese and Western medicine (2017). *Chinese Journal of Integrated Traditional and Western Medicine on Digestion*, **2018**, 26: 18–26

- <https://doi.org/10.3969/j.issn.1671-038X.2018.01.03>
- [22] Zhong, G., Yang, B. *Chinese Materia Medica*. China Press of Traditional Chinese Medicine, Beijing, 2021.
- [23] National Pharmacopoeia Commission. Pharmacopoeia of the People's Republic of China: Part One. China Medical Science and Technology Press, Beijing, 2020.
- [24] ISO 18662-1:2017 Traditional Chinese medicine: Vocabulary Part 1: Chinese Materia Medica. International Organization for Standardization, 2017.
- [25] Sankararaman, S., Velayuthan, S., Chen, Y., et al. Role of Traditional Chinese Herbal Medicines in Functional Gastrointestinal and Motility Disorders. *Current Gastroenterology Reports*, **2022**, 24: 43–51. <https://doi.org/10.1007/s11894-022-00843-8>
- [26] Guo, X., Li, R., Huang, N., et al. Efficacy and safety of Shouhui Tongbian Capsules in the treatment of constipation: A systematic review and meta-analysis. *Phytomedicine*, **2023**, 108: 154541. <https://doi.org/10.1016/j.phymed.2022.154541>
- [27] Xiao, Y., Liu, Y. Y., Yu, K. Q., et al. Chinese herbal medicine liu jun zi tang and xiang sha liu jun zi tang for functional dyspepsia: meta-analysis of randomized controlled trials. *Evidence-Based Complementary and Alternative Medicine*, **2012**, 2012: 936459. <https://doi.org/10.1155/2012/936459>
- [28] Sheng, J. J., Xu, K. Meta-analysis of the efficacy of Jianpi Yiqi Decoction in the treatment of functional dyspepsia. *Women's Health Research*, **2020**: 127–129+194.
- [29] Kim, K., Ko, S. J., Cho, S. H., et al. Herbal medicine, *Banxia-xiexin tang*, for functional dyspepsia: a systematic review and meta-analysis. *Frontiers in Pharmacology*, **2023**, 14: 1130257. <https://doi.org/10.3389/fphar.2023.1130257>
- [30] Wang, Y., Zhang, S., Zhou, Q., et al. Efficacy of Shenlingbaizhu formula on irritable bowel syndrome: a systematic review. *Journal of Traditional Chinese Medicine*, **2020**, 40: 897–907. <https://doi.org/10.19852/j.cnki.jtcm.2020.06.001>
- [31] Khanna, R., Macdonald, J. K., Levesque, B. G. Peppermint oil for the treatment of irritable bowel syndrome: a systematic review and meta-analysis. *Journal of Clinical Gastroenterology*, **2014**, 48: 505–512. <https://doi.org/10.1097/mcg.0b013e3182a88357>
- [32] Yan, J., Cui, Y., Ren, B. A Meta-Analysis of Modified Sijunzi Decoction Combined with Tongxie Yaofang in the Treatment of IBS-D. *Frontiers in Medical Science Research*, **2023**, 5. <https://doi.org/10.25236/FMSR.2023.050917>
- [33] Qian, L., Yong, M. X., Tao, Z. Meta-analysis and trial sequential analysis of the treatment of irritable bowel syndrome with modified Xiaoyao Powder. *World Journal of Integrated Traditional and Western Medicine*, **2020**, 15: 1772–1777. <https://doi.org/10.13935/j.cnki.sjzx.201003>
- [34] Zhou, P., Wang, X., Sun, M., et al. Effects of natural products on functional constipation: analysis of active ingredient and mechanism. *Naunyn-Schmiedeberg's Archives of Pharmacology*, **2024**, 397: 2083–2103. <https://doi.org/10.1007/s00210-023-02786-x>
- [35] Hu, M. L., Rayner, C. K., Wu, K. L., et al. Effect of ginger on gastric motility and symptoms of functional dyspepsia. *World Journal of Gastroenterology*, **2011**, 17: 105–110. <https://doi.org/10.3748/wjg.v17.i1.105>
- [36] Khonche, A., Fallah Huseini, H., Abdi, H., et al. Efficacy of *Mentha pulegium* extract in the treatment of functional dyspepsia: A randomized double-blind placebo-controlled clinical trial. *Journal of Ethnopharmacology*, **2017**, 206: 267–273. <https://doi.org/10.1016/j.jep.2017.05.026>
- [37] Wang, Z., Chen, F., Jiang, W. Clinical study on Amomum villosum lour extract in the treatment of functional dyspepsia due to deficiency of spleen and stomach. *Biomedical Research-tokyo*, **2017**, 28: 9679–9682
- [38] Giacosa, A., Guido, D., Grassi, M., et al. The effect of ginger (*Zingiber officinalis*) and artichoke (*Cynara cardunculus*) extract supplementation on functional dyspepsia: a randomised, double-blind, and placebo-controlled clinical trial. *Evidence-Based Complementary and Alternative Medicine*, **2015**, 2015: 915087. <https://doi.org/10.1155/2015/915087>
- [39] Li, X., Lin, Y., Jiang, Y., et al. Aqueous Extract of *Phyllanthus Emblica* L. Alleviates Functional Dyspepsia Through Regulating Gastrointestinal Hormones and Gut Microbiome in vivo. *Foods*, **2022**, 11. <https://doi.org/10.3390/foods11101491>
- [40] Jin, Y. R., Jin, J., Piao, X. X., et al. The effect of *Taraxacum officinale* on gastric emptying and smooth muscle motility in Rodents. *Neurogastroenterology and Motility*, **2011**, 23: 766–e333. <https://doi.org/10.1111/j.1365-2982.2011.01704.x>
- [41] Allam, S., Krueger, D., Demir, I. E., et al. Extracts from peppermint leaves, lemon balm leaves and in particular angelica roots mimic the pro-secretory action of the herbal preparation STW 5 in the human intestine. *Phytomedicine*, **2015**, 22: 1063–1070. <https://doi.org/10.1016/j.phymed.2015.08.008>
- [42] Zhang, X., Zheng, F. J., Zhang, Z. Therapeutic effect of *Cistanche deserticola* on defecation in senile constipation rat model through stem cell factor/C-kit signaling pathway. *World Journal of Gastroenterology*, **2021**, 27: 5392–5403. <https://doi.org/10.3748/wjg.v27.i32.5392>
- [43] Zhang, H., Zu, Q., Zhang, J., et al. Soluble Dietary Fiber of Hawthorn Relieves Constipation Induced by Loperamide Hydrochloride by Improving Intestinal Flora and Inflammation, Thereby Regulating the Aquaporin Ion Pathway in Mice. *Foods*, **2024**, 13: 2220. <https://doi.org/10.3390/foods13142220>
- [44] Jang, S. H., Yang, D. K. The combination of *Cassia obtusifolia* L. and *Foeniculum vulgare* M. exhibits a laxative effect on loperamide-induced constipation of rats. *PLoS One*, **2018**, 13: e0195624. <https://doi.org/10.1371/journal.pone.0195624>
- [45] Størstved, S., Pontén, I., Simrén, M. A Pilot Study of the Effect of Aloe barbadensis Mill. Extract (AVH200®) in Patients with Irritable Bowel Syndrome: A Randomized, Double-blind, Placebo-controlled Study. *Journal of Gastrointestinal and Liver Diseases*, **2015**, 24: 275–280. <https://doi.org/10.15403/jgld.2014.1121.243.sst>
- [46] Wang, T. Study on the pharmacodynamics and mechanism of visceral hypersensitivity of irritable bowel syndrome using the extracts of *Psoralea Corylifolia* L. and Nutmeg. *Anhui University of Chinese Medicine*, **2016**.
- [47] Yu, L., Huang, C., Yang, W., et al. Aqueous cinnamon extract ameliorates bowel dysfunction and enteric 5-HT synthesis in IBS rats. *Frontiers in Pharmacology*, **2022**, 13: 1010484. <https://doi.org/10.3389/fphar.2022.1010484>
- [48] Li, Y., Lin, Z., Wang, Y., et al. Unraveling the mystery of efficacy in Chinese medicine formula: New approaches and technologies for research on pharmacodynamic substances. *Arabian Journal of Chemistry*, **2022**, 15: 104302. <https://doi.org/10.1016/j.arabjc.2022.104302>
- [49] Kotha, R. R., Luthria, D. L. Curcumin: biological, pharmaceutical, nutraceutical, and analytical aspects. *Molecules*, **2019**, 24. <https://doi.org/10.3390/molecules24162930>
- [50] Yongwatana, K., Harinwan, K., Chirapongsathorn, S., et al. *Curcuma longa* Linn versus omeprazole in treatment of functional dyspepsia: A randomized, double-blind, placebo-controlled trial. *Journal of Gastroenterology and Hepatology*, **2022**, 37: 335–341. <https://doi.org/10.1111/jgh.15705>
- [51] Tu, Y., Luo, X., Liu, D., et al. Extracts of *Poria cocos* improve functional dyspepsia via regulating brain-gut peptides, immunity and repairing of gastrointestinal mucosa. *Phytomedicine*, **2022**, 95: 153875. <https://doi.org/10.1016/j.phymed.2021.153875>
- [52] Hu, Y., Gao, X., Zhao, Y., et al. Flavonoids in *Amomum Tsaoko* Crevost et Lemarie Ameliorate Loperamide-induced Constipation in Mice by Regulating Gut Microbiota and Related Metabolites. *International Journal of Molecular Sciences*, **2023**, 24. <https://doi.org/10.3390/ijms24087191>
- [53] Liu, X., Li, M., Jian, C., et al. *Astragalus* Polysaccharide Alleviates Constipation in the Elderly Via Modification of Gut Microbiota and Fecal Metabolism. *Rejuvenation Research*, **2022**, 25: 275–290. <https://doi.org/10.1089/rej.2022.0039>
- [54] Di Ciaula, A., Portincasa, P., Maes, N., et al. Efficacy of bio-

- optimized extracts of turmeric and essential fennel oil on the quality of life in patients with irritable bowel syndrome. *Annals of Gastroenterology*, **2018**, 31: 685–691. <https://doi.org/10.20524/aog.2018.0304>
- [55] Kim, J. H., Lee, J. H., Jeong, S. M., et al. Effect of ginseng saponins on a rat visceral hypersensitivity model. *Biological and Pharmaceutical Bulletin*, **2005**, 28: 2120–2124. <https://doi.org/10.1248/bpb.28.2120>
- [56] Duan, Y., Huang, J., Sun, M., et al. *Poria cocos* polysaccharide improves intestinal barrier function and maintains intestinal homeostasis in mice. *International Journal of Biological Macromolecules*, **2023**, 249: 125953. <https://doi.org/10.1016/j.ijbiomac.2023.125953>
- [57] Fikree, A., Byrne, P. Management of functional gastrointestinal disorders. *Clinical Medicine*, **2021**, 21: 44–52. <https://doi.org/10.7861/clinmed.2020-0980>
- [58] Holtmann, G., Shah, A., Morrison, M., et al. Pathophysiology of Functional Gastrointestinal Disorders: A Holistic Overview. *Digestive diseases*, **2018**, 35: 5–13. <https://doi.org/10.1159/000485409>
- [59] Vanuytsel, T., Bercik, P., Boeckxstaens, G., et al. Understanding neuroimmune interactions in disorders of gut-brain interaction: from functional to immune-mediated disorders. *Gut*, **2023**, 72: 787–798. <https://doi.org/10.1136/gutjnl-2020-320633>
- [60] Xie, H., Li, H., Zhao, Y., et al. Analysis of dietary exposure and risk assessment of pesticide residues in roots and rhizomes of Chinese herbs. *Journal of Food Science*, **2022**, 87: 124–140. <https://doi.org/10.1111/1750-3841.15994>
- [61] Carstairs, S. D., Cantrell, F. L. The spice of life: an analysis of nutmeg exposures in California. *Clinical Toxicology*, **2011**, 49: 177–180. <https://doi.org/10.3109/15563650.2011.561210>
- [62] Zhang, L., Chen, X., Cheng, Y., et al. Safety and antifatigue effect of Korean Red Ginseng: a randomized, double-blind, and placebo-controlled clinical trial. *Journal of Ginseng Research*, **2019**, 43: 676–683. <https://doi.org/10.1016/j.jgr.2019.05.006>
- [63] Tan, J., Zhang, H., Zhang, L., et al. Ginseng and "Shanghuo" (fireness): a comprehensive review from the viewpoints of TCM theory and modern science. *Food and Function*, **2023**, 14: 3437–3453. <https://doi.org/10.1039/d2fo03873k>
- [64] Huang, H., Li, M., Wang, Y., et al. Excessive Intake of Longan Arillus Alters gut Homeostasis and Aggravates Colitis in Mice. *Frontiers in Pharmacology*, **2021**, 12: 640417. <https://doi.org/10.3389/fphar.2021.640417>
- [65] Sun-Waterhouse, D., Chen, X. Y., Liu, Z. H., et al. Transformation from traditional medicine-food homology to modern food-medicine homology. *Food & Medicine Homology*, **2024**, 1: 9420014. <https://doi.org/10.26599/FMH.2024.9420014>