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Review Article

Functional activity and mechanisms of common marine traditional Chinese medicine

Xian-Wen Lu[1], Song Qin[1, 3], Qi Wang[1, 3], Chen-Yang Lu[2] (✉), Wen-Jun Li[1, 3] (✉)

[1] *Shandong University of Traditional Chinese Medicine, Jinan 250355, China*
[2] *Ningbo University, Ningbo 315832, China*
[3] *Yantai Institute of Coastal Zone Research, Chinese Academy of Science, Yantai 264003, China*

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Abstract: In recent years, the research of marine drugs has become a global hot spot, and marine traditional Chinese medicine (MTCM) is an important part of traditional Chinese medicine. To promote the development and application of MTCM, this review collected 10 kinds of MTCM from the Pharmacopoeia of the People's Republic of China, analyzed and expounded their pharmacological effects. The pharmacological effects of MTCM are mainly anti-inflammation, antioxidation and anticancer, and could be used for the treatment of diabetes, atherosclerosis and other diseases. Modern pharmacological studies have confirmed that the pharmacological effects of MTCM are consistent with those recorded in ancient books, *Ostreae Concha* and *Laminaria Thallus*, as MTCM, have been listed as medicinal and edible substances in China. However, MTCM is facing problems such as lack of quality standards and resource destruction. Therefore, it is necessary to summarize the pharmacological effects and use methods of MTCM, to provide reference for the application and resource development of MTCM.

Keywords: marine; traditional Chinese medicine; activity; mechanism

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1 Introduction

Marine traditional Chinese medicine (MTCM) is an important part of traditional Chinese medicine. Under the guidance of traditional Chinese medicine theory, MTCM refers to drugs derived from marine sources (including seawater itself, coastal beaches, wetlands and saline soil areas outside the sea) for the prevention, diagnosis and treatment of diseases[1]. Marine drugs have become a hot spot in global drug research and development. In 2017 alone, 1490 new compounds from the marine were reported. Currently, 49 active substances in the ocean have been approved for marketing or clinical use in China and internationally. China has a coastline of approximately 1.8 × 10^4 km and a sea area of approximately 4.7 × 10^6 km^2, in recent years. China has accelerated the development and utilization of MTCM, in which drugs such as sodium alginate diester, glycosyl ester and squalene have been approved for listing[2].

Records related to MTCM can be traced back to the Spring and Autumn and Warring States periods. 'Shennong's Herbal Classic' is the earliest existing monograph of traditional Chinese medicine in China. The recorded MTCM includes seaweed, oysters, squid bones, etc. There are 190 kinds of MTCM recorded in 'Compendium of Materia Medica', involving 116 species; Zhonghua Haiyang Bencao, edited by Guan Huashi, published in 2009, included 613 MTCM, involving 1,479 species. The records of the use of MTCM can be traced back to 2,500 years ago. In this paper, 10 kinds of common MTCM were collected., such as sargassum, laminariae thallus, Glehniae Radix, hippocampus, syngnathus, Sepiae Endoconcha, ostreae concha, margarita, margaitifera conch and haliotids concha. Under the guidance of traditional Chinese medicine theory, these MTCMs can be used to treat diseases such as type 2 diabetes, hypertension, atherosclerosis, pulmonary fibrosis, hepatitis and bone hyperplasia (Fig. 1) in China as being used as homology of medicine and food.

Currently, there is no systematic literature on the pharmacological effects of MTCM. Therefore, it is necessary to sort out the pharmacological effects of MTCM. This paper reviews the pharmacological effects of MTCM to provide a reference for the further development of traditional Chinese medicine resources.

2 Herbal MTCM

Herbal medicines of MTCM include *Sargassum*, *Laminariae Thallus* and *Glehniae Radix*. these herbal medicines often have antioxidation, anti-inflammation, antitumor, hypoglycemic, and other effects and can be used for the prevention and treatment of atherosclerosis, hyperglycemia, nervous system diseases, and other diseases (Table 1).

Address correspondence to Chen-Yang Lu, luchenyang@nbu.edu.cn; Wen-Jun Li, wjli@yic.ac.cn

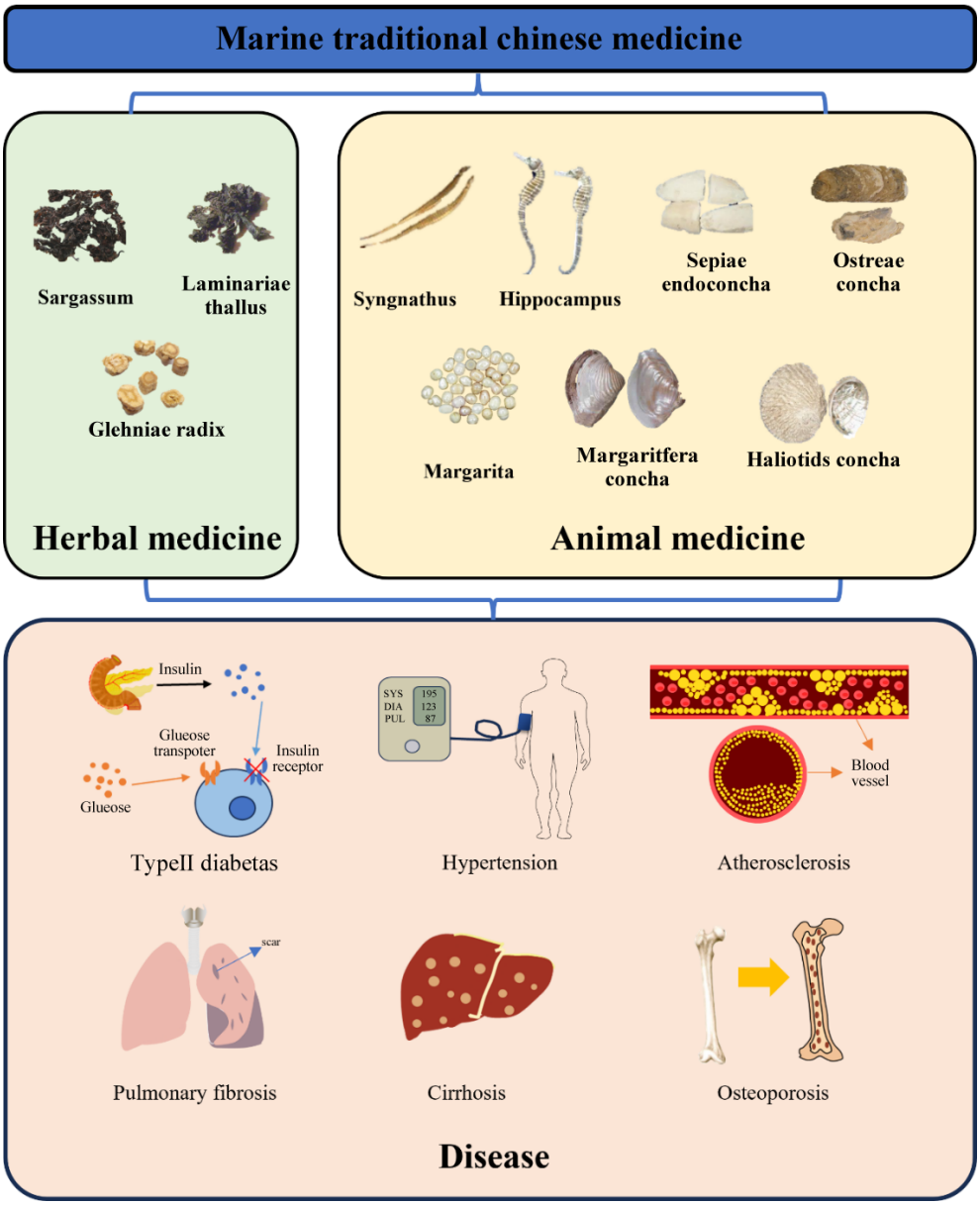

Figure 1 Marine traditional Chinese medicine and its application.

2.1 *Sargassum*

Sargassum is the dried algae of *Sargassum pallidum* (Turn.) C. Ag or *Sargassum fusiforme* (Harv.) Setch.[37]. In recent years, research on the chemical composition of *sargassum* mainly focuses on *sargassum* polysaccharides. The improvement of the quality standard of *sargassum* mainly depends on the improvement of polysaccharide detection technology. Currently, the commonly used polysaccharide detection methods mainly include phenol-sulfuric acid method and anthrone-sulfuric acid method. The common principle is that after the polysaccharide is hydrolyzed by sulfuric acid, it forms a colored complex with phenol or anthrone to measure the polysaccharide content[38]. Modern pharmacological studies have confirmed that *sargassum* polysaccharides have antioxidant, anti-inflammatory, and anti-cancer effects[39]. Wan *et al.*[40] compared hot water extraction, acid-assisted extraction, alkali-assisted extraction, ultrasonic-assisted extraction, microwave-assisted extraction and hydrogen peroxide/ascorbic acid assisted extraction, the results showed that the yield of polysaccharide prepared by hydrogen peroxide/ascorbic acid assisted extraction method was the highest. The reason is that the hydrogen peroxide/ascorbic acid system can produce more hydroxyl radicals, which leads to the cleavage of glycosidic bonds and the degradation of polysaccharides. *In vitro* experiments confirmed that the polysaccharide had good antioxidant activity.

Fang *et al.*[41] found that *sargassum* polysaccharide dose-dependently scavenged ·OH^- and oxyradical (O_2^-). When the polysaccharide concentration was 200 μg/mL, the scavenging rate of ·OH^- was 26%, and the scavenging rate of O_2^- was 80%. In addition, *sargassum* polysaccharide showed some inhibitory effect on lipovitellin. Therefore, *sargassum* polysaccharide is expected to be developed as an antioxidant. A study by Li *et al.*[42] demonstrated that *sargassum* polysaccharides could promote the expression of immune factors (iNOS) and TNF-α and inhibit the proliferation of A549 lung cancer cells. This suggests that *sargassum* polysaccharide not only has immune-enhancing activity but also some antitumor activity. Ding *et al.*[43] showed that *Sargassum fusiforme* polysaccharide could inhibit the proliferative

Table 1 Traditional Chinese herbal medicine from the marine

Herbal medicine	Pharmacological effects	Action mechanism	Reference
Sargassum	Antioxidation	Scavenging of superoxide radicals 1,1-diphenyl-2-picrylhydrazyl (DPPH).	[3]
	Anticancer	Sargassum polysaccharide can increase the levels of tumor necrosis factor-α (TNF-α), interleukin (IL)-1, nitric oxide (NO) and immunoglobulin M in serum (IgM), increase the expression of B-cell lymphoma-2 (Bax), decrease the expression of B-cell lymphoma-2 (Bcl-2), inhibit the proliferation of tumor cells and promote the apoptosis of tumor cells.	[4, 5]
	Hypolipidemic activity	Inhibition of triglyceride and free fatty acid levels in cells; regulate fat production, decomposition and free fatty acid oxidation.	[6, 7]
	Immunoregulation	The number of lymphocytes, bone marrow mononuclear cells and goblet cells in the intestine increased.	[8]
	Anti-inflammation	Decreased the expression of IL-1β, IL-8 and TNF-α, increased the expression of mucin-2, tight junction protein ZO-1 and occludin; regulating gut microbiota composition.	[9, 10]
	Anti-virus	Inhibition of viral replication *in vitro* and *in vivo*.	[11, 12]
	Hypoglycemic	Reduce fasting blood glucose, triglycerides, total cholesterol (TC), increase high-density lipoprotein cholesterol (HDL-c), improve glucose tolerance; increase benign bacteria in the intestine and reduce harmful bacteria; reduced branched chain amino acids and aromatic amino acids in the colon	[13, 14]
	Anti-viral	Upregulation of IRF3 signaling-mediated interferon α (IFN-α)	[15, 16]
	Anti-coagulation	Inhibition of intrinsic factor Xase, prolong the activated partial thromboplastin time (APTT).	[17]
	Anti-atherosclerosis	Regulating autophagy-mediated macrophage polarization alleviates lipid deposition, reduces the expression of M1 macrophage markers, and increases the expression of M2 macrophages.	[18, 19]
	prevent podocyte epithelial–mesenchymal transition	Inhibition of transforming growth factor-β (TGF-β) induced suppressor of mothers against decapentaplegic (Smad)-3, Smad-4 and p38MAPK activation, upregulation of epithelial markers (Nephrin, WT-1, podocin), downregulation of mesenchymal markers (alpha -smooth muscle actin(α-SMA), fibronectin 1(FN-1)) expression.	[20]
Laminariae Thallus	Anticancer	Inhibition of activation of beta-catenin/transcription factor-4 (TCF4) pathway activation, inhibited the protein expression of Ki67 and proliferating cell nuclear antigen (PCNA), downregulated the expression of Bcl-2 while upregulated the expression of Bax, cl-caspase-3, and cl-caspase-9, upregulated the expression of E-cadherin, downregulated the expression of vascular endothelial growth factor (VEGF) and N-cadherin, and downregulated beta-catenin, TCF4, and c-Myc protein expression levels.	[21, 22]
	Anti-obesity	Reduce liver fat accumulation, reduce TC and Low-Density Lipoprotein levels, increase HDL, lipids metabolism enzyme (LPL), Uncoupling Protein 2, peroxisome proliferators-activated receptor (PPAR)-α levels; reduce the levels of inflammatory factors TNF-α and IL-6 in the intestine; increased the abundance of probiotics in the intestine	[23]
	Anti-type 2 diabetes	Lower blood sugar, relieve insulin resistance; increase the abundance of beneficial bacteria in the intestine and reduce the abundance of harmful bacteria; increased the content of moderate bioactive substances in the intestine.	[24, 25]
	Anti-hypertension	Binds to the angiotensin converting enzyme (ACE) active site through hydrogen bonding, forming a very stable complex structure to inactivate the ACE.	[26, 27]
	Anti-allergic reaction	Reduced histamine and IL-4 levels, increased interferon (IFN)-γ levels, increased the number of Treg cells in the tissue, and inhibited Th0 cell differentiation.	[28, 29]
Glehniae Radix	Antibacterial	Inhibit the growth of the growth of *Fusarium solani*, *Fusarium seminudeum*, *Fusarium oxysporum*, Aspergillus parasiticus and Aspergillus flavus.	[30]
	Immunoregulation	The killing rate of natural killer cells and the transformation function of T lymphocytes in spleen were enhanced, and the contents of immunoglobulin M (IgM) and immunoglobulin G (IgG) in serum were increased.	[31]
	Antioxidation	Scavenging of DPPH radical and hydroxyl (·OH^-) radical.	[32, 33]
	Anticancer	Induce cell arrest in S and G2/M phase, inhibit cell proliferation and migration; downregulation of PCNA expression induced apoptosis.	[34]
	Anti-inflammation	Inhibit the expression of inflammatory factors (IL-2, etc.).	[35, 36]

activity of HEL cells, and the inhibitory effect was proportional to the dose. polysaccharide (100 μg/mL) reduced the viability of HEL cells from 100% to 40%.

2.2 *Laminariae Thallus*

The medicinal part of the *Laminaria Thallus* is the dried leafy body of *Laminaria japonica* Aresch. or *Ecklonia kurome* Okam.[37]. *Laminaria thallus* is rich in iodine and polysaccharide compounds. Generally, iodine is determined by potassium iodate method, the pharmacopoeia stipulates that iodine in dried *Laminaria japonica* is not less than 0.35%, and iodine in *laminaria thallus* is not less than 0.20%. Polysaccharides were measured using anthrone-sulfuric acid method. The polysaccharide content in kelp were measured by fucose, not less than 2.0%.

The *laminariae thallus* is known as an iodine-rich herb because of its high iodine content and can be used to treat Graves' disease and hyperthyroidism[44]. Aoe *et al.*[45] studied the effect of *laminariae thallus* on the body composition of overweight subjects. The results showed that the body fat percentage of overweight men who consumed low iodine *laminaria thallus* powder decreased significantly, and had no effect on thyroid secretion. Li *et al.*[46] compared the three methods of hot water extraction, ultrasound-assisted extraction, and enzyme-assisted extraction. The results showed that hot water extraction caused the least structural damage to the polysaccharide, and the polysaccharide extracted by this method had a uniform smooth, sheet structure. The polysaccharide can inhibit the migration of tumor cells and promote tumor cell apoptosis. The antioxidant activity of *laminariae thallus* polyphenols was investigated by Shi *et al.*[47]. *Laminariae thallus* polyphenols (200 μg/mL) showed a scavenging rate of 79.53% for DPPH radicals, 95.25% for ·OH^- and 69.83% for O_2^-, indicating that *laminariae thallus* polyphenols

have antioxidant activity. In addition, *laminariae thallus* was able to inhibit the growth and reproduction of *Escherichia coli*, *Bacillus subtilis*, and *Staphylococcus aureus*, indicating that *laminariae thallus* polyphenols showed some inhibitory effects on gram-negative bacteria. China's first self-developed marine drug, Polysaccharide Sulfate, is a drug with anticoagulant and antithrombotic activity developed from fucoidan, an extract of brown algae.

2.3 Glehniae Radix

The medicinal part of Glehniae Radix is the dry root of *Glehnia littoralis Fr. Schmidt ex Miq.*[37]. Glehniae Radix has active ingredients such as polysaccharides and flavonoids, which have various effects, such as immune regulation, antioxidation, antitumor and anti-inflammation[48]. Yu *et al.*[49] obtained the polysaccharide of Glehniae Radix by water extraction, alcohol precipitation and anion exchange column separation and purification. Compared with the blank control group, Glehniae Radix polysaccharides promoted the proliferation of RAW264.7 cells and mouse spleen lymphocytes and then played an immunoregulatory role. Xu *et al.*[50] used the ethanol reflux method to obtain the extract of Glehniae Radix and extracted it with petroleum ether, ethyl acetate, *n*-butanol, and water to obtain four extracts with different polarities. The content of total flavonoids was determined by the sodium nitrite-aluminum nitrate-sodium hydroxide method, and the scavenging ability of different extracts to DPPH and 2, 2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) free radicals was determined. The results demonstrated that the highest content of total flavonoids in the ethyl acetate phase was 494 mg/g. Additionally, the ethyl acetate phase showed the strongest scavenging ability against DPPH free radicals and ABTS free radicals, outperforming the positive control drug, vitamin C. It was confirmed that the extract in the ethyl acetate phase had good antioxidant capacity, though whether this was due to flavonoids was not confirmed. Du *et al.*[35] obtained a homogeneous polysaccharide composed solely of glucose after hot water extraction, ethanol precipitation, and column chromatography. *In vitro* studies confirmed that the polysaccharide has immunomodulatory, anti-inflammatory, and anti-tumor activities.

3 Animal MTCM

Marine sources of animal medicine packages, which include the hippocampus and syngnathus. These MTCMs are rich in polysaccharides and polypeptides, which have anti-inflammation, antioxidation, anticancer, bone-filling and other effects. Mineral Chinese medicines are mostly derived from the inner shell of cartilaginous animals or the shell of shellfish animals. The efficacy of mineral medicine is mainly to treat gastrointestinal diseases and to have a tranquilizing effect. (Table 2).

3.1 Hippocampus

The source of the hippocampus is the dried body of *Hippocampus kelloggi Jordan* et Snyder, *Hippocampus histrix* Kaup, *Hippocampus kuda* Bleeker, *Hippocampus trimaculatus* Leach, and *Hippocampus japonicus* Kaup[37]. Proteins, peptides and steroids in the hippocampus have anti-inflammatory, antioxidant, and anti-aging effects[89].

Wang *et al.*[90] found that hippocampal active protein could downregulate the mRNA levels of inflammatory factors such as TNF-α, IL-6 and IL-1 in RAW264.7 macrophages induced by LPS, indicating that hippocampal active protein had an anti-inflammatory effect. Chen *et al.*[91] separated and purified the freeze-dried powder of the linear hippocampus using the wet natural sedimentation method to obtain four polypeptide components with different molecular weight segments. The antioxidant activity of these components was studied *in vitro*. The results indicated that the scavenging rates of the 0.43-1.09 kDa and 1.09-2.08 kDa hippocampal polypeptide components against O_2^- were 67.35% and 61.73%, respectively. These components showed better antioxidant activity than other molecular weight hippocampal polypeptide.

3.2 Syngnathus

The source of syngnathus is the dried body of *Solenognathus hardwickii*, *Syngnathoides biaculeatus* or *Syngnathus acus* Linnaeus[37]. Syngnathus is rich in protein and trace elements such as Zn, Mn and Cu. The syngnathus protein has an antitumor effect.

Liu *et al.*[92] treated HeLa cervical cancer cells with syngnathus protein with a molecular weight of 33 kDa. The results showed that syngnathus protein had a significant inhibitory effect on the proliferation of HeLa cells. The early apoptosis rate with 4 mg/mL syngnathus protein was 61.56 ± 1.09%, and the late apoptosis rate was 14.60 ± 0.03. In contrast, the early apoptosis rate of the blank control group was 9.82 ± 0.18%, and the late apoptosis rate was 1.12 ± 0.09%. Syngnathus protein significantly inhibited the proliferation of HeLa cells. Studies by Cai *et al.*[56] showed that sea dragon polypeptides can promote protein expression in AMPK/PGC-1α and Keap1/NRF2 pathways, regulate intestinal microecological balance, and thus exert anti-fatigue effects.

3.3 Sepiae Endoconcha

Sepiae Endoconcha is the dry inner shell of *Sepiella maindroni* de Rochebrune or *Sepia esculenta* Hoyle[37]. Sepiea Endoconcha is rich in calcium carbonate, amino acids, polysaccharides, chitosan, and trace elements such as Na, Fe, Mn, and Si. These substances have the pharmacological effects such as protecting the gastric mucosa, improving hypocalcemia, promoting hemostasis, and bone filling[93]. The main component of cuttlebone is calcium carbonate. The determination method of calcium carbonate content is heating cuttlebone powder, using calcein and ethylenediamine tetraacetic acid disodium to titrate. The pharmacopoeia standards stipulates that the content of calcium carbonate should be no less than 86.0%.

Qiu *et al.*[62] used a rat model of acute gastric mucosal injury to study the protective effect of Sepiae Endoconcha on gastric mucosa. The results showed that Sepiae Endoconcha could prevent indomethacin-induced acute gastric mucosal injury in rats. The mechanism may involve increasing serum EGF secretion and PEG2 synthesis, reducing lipid peroxidation, and increase SOD activity. Jin *et al.*[94] measured that 1 g of Sepiae Endoconcha could neutralize 0.109 mol/L of artificial gastric acid in 140-145 mL by the acid-base neutralization method. Sepiae Endoconcha showed no toxicity or side effects, indicating its potential use as a natural gastric acid drug. Gao *et al*[95] established a fracture model of rat tibia by drilling holes and the expression of type I, II and III procollagen mRNA, TGF-β1 mRNA, bone morphogenetic protein-2 (BMP-2) mRNA, and VEGF mRNA was observed. The results confirmed that Sepiae Endoconcha can play a role in angiogenesis and bone healing by upregulating the levels of type I and III procollagen mRNA and BMP-2 mRNA. The above studies

Table 2 Traditional Chinese animal medicine from the marine

Herbal medicine	Pharmacological effects	Action mechanism	Reference
Hippocampus	Anti-inflammation	Downregulation of iNOS expression and decreased the concentration of NO. Inhibition of p65, inhibitor of nuclear factor kappa-B (IκB), extracellular regulated protein kinases (ERK) phosphorylation; reduce the secretion of TNF-α; inhibition of nuclear factor kappa-B (NF-κB) DNA activity.	[51]
	Anti-fatigue	Reduce the expression of creatine, creatine kinase, lactate dehydrogenase, L-lactate, citrate; increased serum glucose, free fatty acids, hepatic glycogen, adenosine triphosphate, succinate dehydrogenase production; improving mitochondrial function and protecting muscle fibers through the mitogen-activated protein kinase (AMPK)/ PPAR (peroxisome proliferator-activated receptor-gamma)-gamma coactivator-1alpha (PGC-1α) signaling pathway.	[52]
	Antioxidation	Reduce intracellular reactive oxygen species (ROS) levels, scavenging peroxyl radicals.	[53]
Syngnathus	Anticancer	Downregulation of dihydrotestosterone-induced androgen receptor and androgen receptor expression. Induce cancer cell apoptosis and inhibit migration.	[54]
	Antitumor	Induce cancer cell apoptosis and increase the expression of pro-apoptotic proteins (Bax, p53); stimulate lymphocyte division, improve immune system function. Inhibits the growth of cancer cells and induces apoptosis of cancer cells.	[55]
	Anti-fatigue	Inhibit oxidative stress; improve mitochondrial function, increase adenosine triphosphate (ATP) production; regulating gastrointestinal microecological balance.	[56]
	Immunoregulation	Stimulate lymphocyte proliferation, increase the expression of IL-2 and TNF, improve immunity.	[57]
	Bone healing	Increased the number of osteoblasts, osteoclasts, woven bone, lamellar bone, havers system, and bone repair.	[58, 59]
Sepiae Endoconcha	Antibiosis	Inhibit the growth of Vibrio harveyi, Vibrio alginolyticus and *Staphylococcus aureus*	[60]
	Gastric protection	Increased the secretion of epidermal growth factor (EGF) and the synthesis of prostaglandin E2 (PEG2) in serum, decreased lipid peroxidation and increased superoxide dismutase (SOD) activity.	[61, 62]
	Hemostasis	Reduce APTT, prothrombin time; prothrombin promotes the formation of coagulation factors and kallikrein during the formation of thrombin.	[63, 64]
	Anti-osteoporosis	Enhanced the proliferation, differentiation and formation of bone nodules of primary osteoblasts.	[65]
Ostreae concha	Anticancer	Inhibition of cell proliferation, cell cycle arrest in G0/G1 phase; the expression of oncogenes such as c-myc and mutant p53 (MTp53) decreased. The expression of tumor suppressor genes such as cyclin-dependent kinase inhibitor p21 (WAF1/CIP1) and retinoblastoma protein (Rb) was enhanced.	[66, 67]
	Immunoregulation	Repair the damage of spleen and thymus tissue morphology, enhance the level of serum hemolysin, increase the concentration of IL-2, interferon-γ and immunoglobulin.	[68]
	Reduce reproductive damage related to autophagy	Reduce intracellular ROS levels and malondialdehyde (MDA) content. Reducing oxidative stress; increase testosterone levels; regulate cell autophagy.	[69]
	Hypolipidemic	Inhibition of lipid metabolism synthesis gene expression, inhibition of lipid biosynthesis and accumulation; reducing cholesterol synthesis and increasing the conversion of cholesterol to bile acid; promote the discharge of fatty acids.	[70]
	Hypoglycemic	Inhibition of α-glucosidase activity.	[70]
Margarita	Wound repair and regeneration	Increase the proliferation and migration of skin cells, enhance the biomechanical strength of healed skin; improve the formation and regular deposition of collagen, enhance skin angiogenesis.	[71, 72]
	Tranquilization	The abnormal gene expression caused by insufficient sleep was corrected by retrograde endocannabinoid signaling pathway, and the protein interaction.	[73, 74]
	Anti-photoaging property	Upregulated the activity of catalase (CAT), glutathione peroxidase (GSH-Px) and SOD, decreased the level of MDA, and inhibited the production of IL-1β, IL-6, Prostaglandin E2, TNF-α and Cyclooxygenase-2.	[75]
	Inhibiting granulosa cell apoptosis	Inhibit the expression of cleaved-caspase3 and Bax through MAPK pathway.	[76]
	Antioxidation	Scavenging hydroxyl radicals; inhibition of tyrosinase activity.	[77, 78]
Margaritifera concha	Antihypertensive	Competitive inhibition of angiotensin I converting enzyme activity	[79]
	Tranquilization	Increase the expression of 5-hydroxytryptamine (HT) $_{1A}$ receptor and decrease the expression of 5-HT 2A receptor. Restoring the normal expression of brain-derived neurotrophic factor (BDNF).	[80]
	Osteogenic	Promote osteoblast proliferation and inhibit osteoclast formation; accelerate preosteoblast differentiation and extracellular matrix mineralization; prevent bone loss.	[81, 82]
	Proangiogenic	Add/synergize with growth factors in cells to increase cell differentiation and functional properties.	[83]
Haliotids Concha	Antioxidation	Scavenging superoxide free radicals.	[84]
	Antihypertensive	Downregulate plasma norepinephrine, epinephrine, angiotensin II, aldosterone levels; upregulate plasma NO levels	[85]
	Repair effect on the ocular surface	Protect conjunctival goblet cells, inhibit ocular surface cell apoptosis, and inhibit ocular surface $CD4^+T$ cells.	[86]
	Anti-inflammation	Inhibition of iNOS expression and removal of neutrophils by phagocytosis. Induces the secretion of transforming growth factor beta1 (TGF-β1), converting collagen during the tissue remodeling phase.	[87]
	Osteogenic	Promote the proliferation and differentiation of osteoblasts and promote bone remodeling.	[88]

have shown that Sepiae Endoconcha has therapeutic effects on gastric mucosal injury and bone healing.

3.4 Ostreae Concha

Ostreae concha is the shell of *Ostrea gigas* Thunberg, *Ostrea talienwhanensis* Crosse, and *Ostrea rivularis* Gould[37]. Ostreae concha are rich in peptides, polysaccharides, amino acids, taurine and other active substances, which have antitumor, hypoglycemic, immunoregulatory and other functions[96]. The main component in ostreae concha is calcium carbonate. According to the

pharmacopoeia, the content of calcium carbonate in oysters is not less than 94.0%.

Xu *et al.*[97] used cyclophosphamide (CTX)-induced immunocompromised female ICR mice as a model to observe the effects of different doses of ostreae concha peptides on immune function in mice. The results showed that the ostreae concha peptide could improve the atrophy and cell reduction of immune organs in CTX-induced immunosuppressed mice. The mechanism may be related to regulating the distribution of T lymphocytes in immunosuppressed mice, regulating the secretion of interleukin 5 (IL-5) and interleukin 7 (IL-7), and restoring the normal proliferation of bone marrow. To explore the protective effect of oyster polysaccharides on acute alcoholic liver injury, Hou *et al.*[98] found that oyster polysaccharides can reduce the activity of alanine aminotransferase and aspartate aminotransferase in the serum of mice with liver injury caused by ethanol gavage, increase the levels of SOD and alcohol dehydrogenase, improve the antioxidant capacity of liver cells, and reduce the damage of alcohol to the liver. The mechanism by which oyster polysaccharides protect against liver injury may be by improving the antioxidant capacity of hepatocytes, protecting the structural integrity and function of hepatocytes, and antagonizing alcohol damage to hepatocytes.

3.5 Margarita

Margarita are calcium carbonate-containing mineral beads formed by the stimulation of bivalves such as the pearl shell animal *Pteria martendsii* (Dunker), *Hyriopsis cumingii* (Lea), or *Crustaria plicata* (Leach)[37]. Margarita is rich in calcium carbonate, amino acids, trace elements, and a variety of proteins. It has conglutinant, anticonvulsant and other activities, and it is often used to treat recurrent aphthous ulcers, gastric ulcers, duodenal ulcers and other diseases.

By comparing the protein release of pearl powder with 544 nm, 2 mm and 67 mm margarita sizes and the healing effect on rat skin wounds, Chen[71] showed that with the decrease in margarita powder, the protein release increased, which promoted the growth and reproduction of fibroblasts, increased skin tensile strength, promoted the formation of new blood vessels, and improved the wound healing rate. Nanosized margarita powder has the best effect on improving the tensile strength of the wound, which can increase the tensile strength of the wound to 15 N. The skin tensile strength of ordinary pearl powder and micron-sized pearl powder is between 10-15 N, and that of the blank control group is less than 5 N. Zhang *et al.*[74] studied the anticonvulsant and sedative effects of pearls. The results showed that the water-soluble protein extracted from pearls could reduce 5-HT in brain tissue from 0.55 ng/mL to 0.4 ng/mL. After freeze-drying with dilute hydrochloric acid, the protein reduced the 5-HT level to 0.3 ng/mL. Both water-soluble protein and acid-soluble protein could restore γ-aminobutyric acid from 1.5 ng/mL to 2.7 ng/mL.

3.6 Margaritfera Concha

Margaritfera concha is the shell of the aforementioned pearl. Margaritfera concha consists of calcium carbonate, which induces skeletogenesis in vertebrates. Jean-Daniel[99] compared the osseointegration and erosion of pearl-layer screws with titanium screws *in vivo* in rats implanted with mother-of-pearl screws in the right condyle and titanium screws in the left condyle after anesthesia and showed that the volume of pearl-layer screws decreased over time, with a large difference between pearl screws and titanium screws at 6 months and no significant difference by 12 months. There was no significant difference at 12 months. The erosion of the pearl screws occurred only within the diaphysis, and the screw portion outside the diaphysis did not change, suggesting that the pearl layer screws are only resorbed when in contact with the bone marrow. Therefore, the pearl layer screws can be used as a bone graft substitute under partial conditions and avoid the step of surgical removal of the device after bone healing. Yamagami *et al.*[100] treated rats to study the effect of margarit concha powder on scopolamine-induced memory impairment by the Y-maze experiment, Banes maze experiment and object recognition test. It was found that mother-of-pearl extract could improve scopolamine-induced memory impairment in mice. For further study, a sulfated polysaccharide was extracted from margarit concha, which was found to mediate its antiamnesic effects by preventing oxidative stress and inflammation and increasing the expression levels of BDNF and nerve growth factor.

3.7 Haliotids Concha

Haliotids Concha is the shell of *Haliotis diversicolor* Reeve, *Haliotis discus hannai* Ino, *Haliotis ovina* Gmelin, *Haliotis ruber* (Leach), *Haliotis asinine* Linnaeus, and *Haliotis laevigata* (Donovan)[37]. Modern studies have shown that haliotids concha have pharmacological effects, such as antihypertensive, antibacterial, and neutralizing effects on gastric acid. The pharmacopoeia stipulates that the calcium carbonate content of this product is not less than 95.0%.

Wan[86] used haliotids concha powder in a dry environment and scopolamine-induced immunodeficient dry eye mice to observe the therapeutic effect of haliotid concha on dry eye and study its mechanism. Haliotid concha achieved a damage repair effect on the ocular surface by protecting conjunctival cupped cells, inhibiting apoptosis of ocular surface cells, and suppressing ocular surface $CD4^+$ T cells to reduce dry eye. Wang *et al.*[84] extracted a heteropolysaccharide from the shell of *Haliotis discus hannai* Ino, which has significant superoxide radical scavenging ability. Liu *et al.*[101] confirmed that the haliotid concha has a strong and lasting hypotensive effect, can inhibit the growth of *Pseudomonas aeruginosa* and has a bacteriostatic effect.

4 Prospects

As research on MTCM pharmacology deepens, the efficacy of MTCM has been gradually confirmed. The ancient books shows that sargassum has the function of clearing phlegm and softening hardness. It can be used to treat diseases such as gall tumors and scrofula. Now it is mainly used to treat diseases such as goiter, thyroid tumors and lymphatic tuberculosis. These diseases are the same as those recorded in ancient books[102]. The Sepiae Endoconcha has the effects of astringing hemostasis, astringing essence and stopping belt, relieving acid, relieving pain, astringing dampness and astringing sores. It can be used to treat diseases such as uterine bleeding, pannus and sores. Modern clinical application follows the application of Sepiae Endoconcha in ancient books, which is mostly used to neutralize gastric acid, protect mucosa and stop bleeding[103, 104].

MTCM has the characteristics of complex pharmacological effects, multiple components and targets. These characteristics make it difficult to systematically study the targets and mechanisms of MTCM, in recent years, technologies such as network pharmacology and big data have developed rapidly, which have had a significant impact on MTCM research. They are

widely used in the screening of active ingredients, the positioning of action targets, and the interpretation of the mechanism of multicomponent, multitarget and multi-pathway MTCM. Therefore, the establishment of the chemical molecular database of MTCM, the active ingredient-gene database of marine, and the active ingredient-target database of marines is helpful to provide the basis for the study of the targets and mechanisms of MTCM *in vivo* by using network pharmacology.

As the marine economy has developed by leaps and bounds, the unreasonable development of resources and environmental damage have threatened the sustainable development of MTCM resources, and frequent human activities and dense populations have brought great challenges to the protection and development of MTCM resources. For example, mangroves, which are typical coastal plants and can be used as MTCM resources, have great development potential as MTCM. However, mangroves are facing problems such as area reduction, habitat degradation and biodiversity reduction, making them protected species in China. Therefore, it will be an important measure for the sustainable development of MTCM resources to establish a germplasm bank of MTCM resources, strengthen the system construction of rare and endangered MTCM resources and protect wild MTCM resources.

The complexity of MTCM and its preparation components, the instability and trace of secondary metabolites lead to the uncertainty of the efficacy of most traditional Chinese medicines. At the same time, the detection of one or several components of a traditional Chinese medicine cannot reflect the overall efficacy of traditional Chinese medicine, resulting in the lack of quality standards for MTCM. With the development of science and technology, the technologies for drug identification are becoming more and more perfect. The quality control standards of traditional Chinese medicine in 'Pharmacopoeia' are becoming more and more complete, including chromatography including thin layer chromatography and high-performance liquid chromatography, ultraviolet spectrophotometry and other spectroscopy, DNA barcoding technology and inductively coupled plasma mass spectrometry. In addition, the fingerprint of traditional Chinese medicine is widely used in the quality control of MTCM in recent years because it can comprehensively reflect the types and contents of medicinal materials.

In this paper, only a small part of MTCM resources was listed. Although the types of MTCM have increased rapidly in recent years, the newly added drugs have not been clinically applied due to the lack of records of efficacy and toxicity and incomplete information on functional indications. Therefore, it is necessary to systematically sort out and excavate the research system and evaluate the drug efficacy and toxicity of MTCM, which is conducive to overcoming the problems of drug efficacy and toxicity evaluation and quality control of MTCM and expanding the clinical application of MTCM.

5 Conclusion

MTCM has many activities such as anti-inflammatory, anti-oxidation and anti-tumor. Therefore, accelerating the industrialization of MTCM and contributing a force to the construction of healthy China will help promote MTCM to the world. China has a long cultural history and rich resources in MTCM. However, due to the imperfect information of MTCM, the industrialization of MTCM is restricted. However, with the continuous improvement of the status of traditional Chinese medicine industry in the economic society and the growing health needs of the people, the people's recognition of traditional Chinese medicine is increasing, and the products related to MTCM are gradually infiltrated into people's daily life. Although the development and utilization of MTCM mostly stay in food and health products, with the progress of science and technology and the support of national policies, the level of MTCM industry will be continuously improved. So as to promote the common development of traditional marine Chinese medicine and healthy China.

Conflicts of interest

The authors declare that there are no conflict of interest in this work. Chenyang Lu is an associate editor of Food & Medicine Homology, but was not involved in the processing, peer review or decision making of this article.

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Authors' contributions

All authors contributed to the study conception and design. Xianwen Lu performed the original draft; Song Qin, Qi Wang and Chenyang Lu performed the review and editing; Wenjun Li performed the funding acquisition.

References

[1] Fu, X. J., Wang, Z. G., Wu, J. B., et al. Research on innovation project of marine traditional Chinese medicine. *Chinese Journal of Marine Drugs*, **2020**, 39: 63–70. https://doi.org/10.13400/j.cnki.cjmd.2020.04.010

[2] Qin, K. M., Shi, D. H., Dong, Z. B., et al. Present situation and countermeasure of comprehensive exploitation and utilization of marine traditional Chinese medicine resources. *Chinese Traditional and Herbal Drugs*, **2020**, 51: 5093–5098. https://doi.org/10.7501/j.issn.0253-2670.2020.19.030

[3] Lin, Z. Y., Wang, F. W., Yan, Y. W., et al. Fucoidan derived from *Sargassum pallidum* alleviates metabolism disorders associated with improvement of cardiac injury and oxidative stress in diabetic mice. *Phytotherapy Research*, **2023**, 37: 4210–4223. https://doi.org/10.1002/ptr.7901

[4] Fan, S. R., Zhang, J. F., Nie, W. J., et al. Antitumor effects of polysaccharide from *Sargassum fusiforme* against human hepatocellular carcinoma HepG2 cells. *Food and Chemical Toxicology*, **2017**, 102: 53–62. https://doi.org/10.1016/j.fct.2017.01.020

[5] Yu, M., Ji, Y. B., Qi, Z., et al. Anti-tumor activity of sulfated polysaccharides from *Sargassum fusiforme*. *Saudi Pharmaceutical Journal*, **2017**, 25: 464–468. https://doi.org/10.1016/j.jsps.2017.04.007

[6] Lee, H. G., Kang, M. C., Jeon, Y. J., et al. Inhibitory effect of sulfated polysaccharide from *Sargassum thunbergii* in PA-induced lipid accumulation in vitro. *Food Bioscience*, **2023**, 51: 102144. https://doi.org/10.1016/j.fbio.2022.102144

[7] Tang, M. T., Jiang, H., Wan, C., et al. Hypolipidemic activity and mechanism of action of *Sargassum fusiforme* polysaccharides. *Chem Biodivers*, **2023**, 20: e202300264. https://doi.org/10.1002/cbdv.202300264

[8] Hu, P., Xue, R., Li, Z. X., et al. Structural investigation and immunological activity of a heteropolysaccharide from *Sargassum*

fusiforme. *Carbohydrate Research*, **2014**, 390: 28–32. https://doi.org/10.1016/j.carres.2014.02.027

[9] Fu, Y. H., Tao, X. Y., Yang, D., et al. Anti-adhesive properties of calcium alginate from *Sargassum fusiforme* against particulate matter-induced inflammation. *Current Issues in Molecular Biology*, **2022**, 44: 626–639. https://doi.org/10.3390/cimb44020043

[10] Chen, X. Y., Li, X., Sun-Waterhouse, D., et al. Polysaccharides from *Sargassum fusiforme* after UV/H_2O_2 degradation effectively ameliorate dextran sulfate sodium-induced colitis. *FOOD & FUNCTION*, **2021**, 12: 11747–11759. https://doi.org/10.1039/d1fo02708e

[11] Jyotsna, Vijayakumar, P., Dhas, T. S., et al. Antiviral activity of sulfated polysaccharides from *Sargassum ilicifolium* against fish Betanodavirus infection. *Aquaculture International*, **2021**, 29: 1049–1067. https://doi.org/10.1007/s10499-021-00675-9

[12] Feng, G. R., Zhang, D., Peng, C. C., et al. Study on the anti-adenovirus mechanism of *Sargassum fusiforme*. *Frontiers in Cellular and Infection Microbiology*, **2022**, 12: 860559. https://doi.org/10.3389/fcimb.2022.860559

[13] Liu, J., Wu, S., Cheng, Y., et al. *Sargassum fusiforme* alginate relieves hyperglycemia and modulates intestinal microbiota and metabolites in type 2 diabetic mice. *Nutrients*, **2021**, 13: 2887. https://doi.org/10.3390/nu13082887

[14] Li, Z., Jia, R., Wu, J., et al. *Sargassum fusiforme* polysaccharide partly replaces acarbose against type 2 diabetes in rats. *International Journal of Biological Macromolecules*, **2021**, 170: 447–458. https://doi.org/10.1016/j.ijbiomac.2020.12.126

[15] Cao, Y. G., Hao, Y., Li, Z. H., et al. Antiviral activity of polysaccharide extract from *Laminaria japonica* against respiratory syncytial virus. *Biomedicine & Pharmacotherapy*, **2016**, 84: 1705–1710. https://doi.org/10.1016/j.biopha.2016.10.082

[16] Yue, Y. Y., Li, Z. H., Li, P., et al. Antiviral activity of a polysaccharide from *Laminaria japonica* against enterovirus 71. . *Biomedicine & Pharmacotherapy*, **2017**, 96: 256–262. https://doi.org/10.1016/j.biopha.2017.09.117

[17] Li, T. T., Ma, H. Q., Li, H., et al. Physicochemical properties and anticoagulant activity of purified heteropolysaccharides from *Laminaria japonica*. *Molecules*, **2022**, 27: 3027. https://doi.org/10.3390/molecules27093027

[18] Li, X. Y., Wang, Y. J., Chen, S., et al. *Laminaria japonica* polysaccharide suppresses stherosclerosis via regulating autophagy-mediated macrophage polarization. *Journal of Agricultural and Food Chemistry*, **2022**, 70: 3633–3643. https://doi.org/10.1021/acs.jafc.1c07483

[19] Li, Q. M., Zha, X. Q., Zhang, W. N., et al. *Laminaria japonica* polysaccharide prevents high-fat-diet-induced insulin resistance in mice via regulating gut microbiota. *FOOD & FUNCTION*, **2021**, 12: 5260–5273. https://doi.org/10.1039/d0fo02100h

[20] Li, X. Y., Chen, H. R., Kuang, D. D., et al. *Laminaria japonica* polysaccharide attenuates podocyte epithelial-mesenchymal transformation via TGF-β1-mediated Smad3 and p38MAPK pathways. *International Journal of Biological Macromolecules*, **2023**, 241: 124637. https://doi.org/10.1016/j.ijbiomac.2023.124637

[21] Lin, T. Y., Lo, H. C., Qiu, W. L., et al. Biochemical characterization and anti-cancer activity of tangential flow filtration system assisted purification of fucoglucan from *Laminaria japonica*. *International Journal of Biological Macromolecules*, **2023**, 227: 1–9. https://doi.org/10.1016/j.ijbiomac.2022.12.078

[22] Yao, M. X., Qian, X. J., Qin, H. Y. Effects of *Laminaria Japonica* polysaccharides on the survival of non-small-cell lung cancer A549 cells. *International Journal of Polymer Science*, **2019**, 2019: 1–9. https://doi.org/10.1155/2019/7929535

[23] Jang, W. S., Choung, S. Y. Antiobesity Effects of the ethanol extract of *Laminaria japonica* areshoung in high-fat-diet-induced obese rat. *Evidence-Based Complementary and Alternative Medicine*, **2013**, 2013: 1–17. https://doi.org/10.1155/2013/492807

[24] Zhang, C. X., Jia, J. H., Zhang, P. P., et al. Fucoidan from *Laminaria japonica* ameliorates type 2 diabetes mellitus in association with modulation of gut microbiota and metabolites in streptozocin-treated mice. *Foods*, **2023**, 12: 33. https://doi.org/10.3390/foods12010033

[25] Wang, J., Chen, Y., Zhong, H., et al. The gut microbiota as a target to control hyperuricemia pathogenesis: Potential mechanisms and therapeutic strategies. *Crit Rev Food Sci Nutr*, **2022**, 62: 3979–3989. https://doi.org/10.1080/10408398.2021.1874287

[26] Wang, J., Ye, X., Su, Z., et al. ACE-inhibitory peptides from *Laminaria japonica* and their potential anti-hypertensive mechanism. *CyTA - Journal of Food*, **2021**, 19: 333–340. https://doi.org/10.1080/19476337.2021.1900923

[27] Li, J., Wang, S. Y., Yang, X. M, et al. Effect of sulfated polysaccharides from *Laminaria japonica* on vascular endothelial cells in psychological stress rats. *JOURNAL OF ETHNOPHARMACOLOGY*, **2014**, 151: 601–608. https://doi.org/10.1016/j.jep.2013.11.014

[28] Yu, B. M., Bi, D. C., Yao, L. J., et al. The inhibitory activity of alginate against allergic reactions in an ovalbumin-induced mouse model. *FOOD & FUNCTION*, **2020**, 11: 2704–2713. https://doi.org/10.1039/d0fo00170h

[29] Chen, Y., Lin, H., Li, Z. X., et al. The anti-allergic activity of polyphenol extracted from five marine algae. *Journal of Ocean University of China*, **2015**, 14: 681–684. https://doi.org/10.1007/s11802-015-2601-5

[30] Yang, Z. M., Li, B., Mao, F. Y., et al. Study on the extraction and antifungal activity of volatile oil from stems, leaves and roots of Glehnia. *China Pharmacy*, **2023**, 34: 1358–1362. https://doi.org/10.6039/j.issn.1001-0408.2023.11.14

[31] Rong, L. X., Lu, S., Liu, Y. M. Immunomodulatory effects of *Glehnia Radix* polysaccharide on Yin Deficiency hyperthyroidism Mice. *Chinese Journal of Basic Medicine in Traditional Chinese Medicine*, **2013**, 19: 640–641. https://doi.org/10.19945/j.cnki.issn.1006-3250.2013.06.019

[32] Jing, Y. S., Jin, S., Zhang, D. S., et al. Ethanol fractional purification,physicochemical properties and antioxidant activity polysaccharides from *Glehnia Radix*. *Food & MACHINERY*, **2020**, 36: 178–180. https://doi.org/10.13652/j.issn.1003-5788.2020.07.036

[33] Jing, Y. S., Zhang, R. J., Wu, L. F., et al. Structural characteristics and antioxidant activity of polysaccharide-iron complex from *Glehniae Radix*. *International Journal of Food Properties*, **2020**, 23: 894–907. https://doi.org/10.1080/10942912.2020.1770787

[34] Wu, J., Gao, W. P., Song, Z. Y., et al. Anticancer activity of polysaccharide from *Glehnia littoralis* on human lung cancer cell line A549. *International Journal of Biological Macromolecules*, **2018**, 106: 464–472. https://doi.org/10.1016/j.ijbiomac.2017.08.033

[35] Du, B. X., Fu, Y. P., Wang, X., et al. Isolation, purification, structural analysis and biological activities of water-soluble polysaccharide from *Glehniae radix*. *International Journal of Biological Macromolecules*, **2019**, 128: 724–731. https://doi.org/10.1016/j.ijbiomac.2019.01.159

[36] Du, B. X. Isolation, purification, structural analysis and biological activities of water-soluble polysacharide from the root of Glehnia littoralis. Shandong University of Traditional Chinese Medicine, Jinan, 2019.

[37] Commission, C. P. *Pharmacopoeia of the People's Republic of China* 2020. China Medical Science Press: Beijing, Beijing, **2020**.

[38] Xiong, Y., Wu, S. Q. Research progress on quality standard and quality control method of haizao (*Sargassum*). *Guiding Journal of Traditional Chinese Medicine and Pharmacy*, **2022**, 28: 85–90+99. https://doi.org/10.13862/j.cn43-1446/r.2022.10.020

[39] Zhang, R., Zhang, X. X., Tang, Y. X., et al. Composition, isolation, purification and biological activities of *Sargassum fusiforme* polysaccharides: A review. *Carbohydrate Polymers*, **2020**, 228: 115381. https://doi.org/10.1016/j.carbpol.2019.115381

[40] Wan, C., Jiang, H., Tang, M. T., et al. Purification, physico-chemical properties and antioxidant activity of polysaccharides from *Sargassum fusiforme* by hydrogen peroxide/ascorbic acid-assisted extraction. *International Journal of Biological*

Macromolecules, **2022**, 223: 490–499. https://doi.org/10.1016/j.ijbiomac.2022.11.030

[41] Fang, F., Tang, Z. H. Study on the antioxidant activity of polysaccharide from *S. pallidium*. *Journal of Anhui Agricultural Sciences*, **2011**, 39: 9590–9591. https://doi.org/10.13989/j.cnki.0517-6611.2011.16.200

[42] Li, Y. Z., Yu, Z. Y., Tian, X., et al. Physicochemical properties and immunomodulatory activities of crude polysaccharides isolated from *Sargassum pallidum*. *Marine Sciences*. **2020**, 44: 10–18. https://doi.org/10.11759/hykx20200418002

[43] Ding, H. M., Du, H. F, Fu, R. J, et al. Analysis of differentially expresses genes in human erythroleukemia cells induced by sulfated polysaccharide fraction From *Sargassum fusiforme*. *Journal of Nuclear Agricultural Sciences*, **2021**, 35: 595–604. https://doi.org/10.11869/j.issn.100-8551.2021.03.0595

[44] Gao, T. Expert consensus on the treatment of Graves ' disease with iodine-rich traditional Chinese medicine. *Chinese Journal of Integrated Traditional and Western Medicine*, **2021**, 41: 663–667. https://doi.org/10.7661/j.cjim.20210409.071

[45] Aoe, S., Yamanaka, C., Ohtoshi, H., et al. Effects of daily Kelp (*Laminaria japonica*) intake on body composition, serum lipid levels, and thyroid hormone levels in healthy Japanese adults: A Randomized, Double-Blind Study. *Marine Drugs*, **2021**, 19. https://doi.org/10.3390/md19070352

[46] Li, Y., Qin, G. X., Cheng, C., et al. Purification, characterization and anti-tumor activities of polysaccharides from *Ecklonia kurome* obtained by three different extraction methods. *International Journal of Biological Macromolecules*, **2020**, 150: 1000–1010. https://doi.org/10.1016/j.ijbiomac.2019.10.216

[47] Shi, J. X., Chen, G., Li, D. L., et al. Ultrasonic assisted extraction of Kelp Polyphenols and analysis of its antibacterial activity. *Food Research and Development*, **2017**. 38: 50–55. https://lib.cqvip.com/Qikan/Article/Detail?id=672031344

[48] Jing, Y. S., Zhang, H., Cheng, W. J., et al. Research progress on extraction process, physicochemical properties and biological activity of polysaccharides from Glehniae Radix. *Journal of Food Safety and Quality*, **2022**, 13: 2610–2617. https://doi.org/10.19812/j.cnki.jfsq11-5956/ts.2022.08.032

[49] Yu, Q. H., Du, B. X., Du, Y. Q., et al. Effect of separation and purification of polysaccharide from glehnia radix and its degradation by intestinal flora on proliferation of immune cells *in vitro*. *Chinese Traditional Patent Medicine*, **2020**, 42: 1362–1366. https://qikan.cqvip.com/Qikan/Article/Detail?id=7101733282

[50] Xu, Y. P., Cui, H. Y., Shen, W., et al. *In Vitro* Antioxidant activity of ethanol extract from stems and leaves of Glehnia littoralis and its different polarity fractions. *Traditional Chinese Drug Research and Clinical Pharmacology*, **2019**, 30: 785–789. https://doi.org/10.19378/j.issn.1003-9783.2019.07.005

[51] Zhang, Y. Y., Ryu, B. M., Cui, Y. H., et al. A peptide isolated from *Hippocampus abdominalis* improves exercise performance and exerts anti-fatigue effects via AMPK/PGC-1α pathway in mice. *Journal of Functional Foods*, **2019**, 61: 103489. https://doi.org/10.1016/j.jff.2019.103489

[52] Zhang, Y., Li, C. Y., Zhou, C. X., et al. 2 ′ -Hydroxy-5'-methoxyacetophenone attenuates the inflammatory response in LPS-induced BV-2 and RAW264.7 cells via NF-κB signaling pathway. *Journal of Neuroimmunology*, **2019**, 330: 143–151. https://doi.org/10.1016/j.jneuroim.2019.03.009

[53] Kim, H. S., Kim, S. Y., Fernando, I. P. S., et al. Free radical scavenging activity of the peptide from the Alcalase hydrolysate of the edible aquacultural seahorse (*Hippocampus abdominalis*). *Journal of Food Biochemistry*, **2019**, 43. https://doi.org/10.1111/jfbc.12833

[54] Ghasemi, A., Ghavimi, R., Momenzadeh, N., et al. Characterization of antitumor activity of a synthetic moronecidin-like peptide computationally predicted from the tiger tail *Seahorse Hippocampus Comes* in Tumor-bearing Mice. *International Journal of Peptide Research and Therapeutics*, **2021**, 27: 2391–2401. https://doi.org/10.1007/s10989-021-10260-6

[55] Wang, M. M., Nie, Y. X., Peng, Y., et al. Purification, characterization and antitumor activities of a new protein from *Syngnathus acus*, an Officinal Marine Fish. *Marine Drugs*, **2012**, 10: 35–50. https://doi.org/10.3390/md10010035

[56] Cai, B. N., Yi, X. X., Wang, Z., et al. Anti-fatigue effects and mechanism of *Syngnathus schlegeli* peptides supplementation on exercise-fatigued mice. *Journal of Functional Foods*, **2023**, 110: 105846. https://doi.org/10.1016/j.jff.2023.105846

[57] Li, C. C. Study on effects of syngnthus, acus linnaeus extracts on human lymphocytes *in Vitro*. *Journal of Anhui Agricultural Sciences*, **2009**, 37: 1096–1097. https://doi.org/10.13989/j.cnki.0517-6611.2009.03.144

[58] Aminatun, A., Handayani, F., Widiyanti, P., et al. *In vivo* approach on femur bone regeneration of white rat (*Rattus norvegicus*) with the use of hydroxyapatite from cuttlefish bone (*Sepia* spp.) as bone filler. *Vet World*, **2019**, 12: 809–816. https://doi.org/10.14202/vetworld.2019.809-816

[59] Dogan, E., Okumus, Z. Cuttlebone used as a bone xenograft in bone healing. *Veterinární medicína*, **2014**, 59: 254–260. https://doi.org/10.17221/7519-vetmed

[60] Zhu, W. J., Chen, S. Q., Xie, G. S., et al. The study on treatment method and antibacterial activity of three cuttlebone. *Periodical of Ocean University of China*, **2021**, 12: 50–57. https://doi.org/10.16441/j.cnki.hdxb.20210064

[61] Chien, M., Lin, Y. T., Peng, F. C., et al. Gastroprotective potential against indomethacin and safety assessment of the homology of medicine and food formula cuttlebone complex. *FOOD & FUNCTION*, **2015**, 6: 2803–2812. https://doi.org/10.1039/c5fo00638d

[62] Qiu, L. F. Effect of cuttlebone on healing of indometacin-induced acute gastric mucosal lesion in rats. Zhejiang Unversity, Hangzhou, 2014.

[63] Liu, S. H., Wang, Y. X., Shao, Z. B., et al. Analysis of active components and hemostatic mechanism of sepiae endoconcha extract. *Chinese Traditional Patent Medicine*, **2022**, 10: 3366–3368. https://doi.org/10.3969/j.issn.1001-1528.2022.10.057

[64] Yu, X. R., Ma, Y. H., Ma, Z. K., et al. Nanofiber membrane prepared from a marine organism-based material cuttlebone combined with gelatin for rapid hemostasis. *Journal of Materials Science*, **2023**, 58: 13762–13773. https://doi.org/10.1007/s10853-023-08892-8

[65] Han, S. Y., Lee, J. R., Kwon, Y. K., et al. Ostreae Testa prevent ovariectomy-induced bone loss in mice by osteoblast activations. *JOURNAL OF ETHNOPHARMACOLOGY*, **2007**, 114: 400–405. https://doi.org/10.1016/j.jep.2007.08.019

[66] Umayaparvathi, S., Arumugam, M., Meenakshi, S., et al. Purification and characterization of antioxidant peptides from oyster (*Saccostrea cucullata*) hydrolysate and the anticancer activity of hydrolysate on human colon cancer cell Lines. *International Journal of Peptide Research and Therapeutics*, **2014**, 20: 231–243. https://doi.org/10.1007/s10989-013-9385-5

[67] Li, Q. F., Huang, D. C., Shi, S. L., et al. The regulation effects of bioactive peptides of oyster (BPO-L) on the cell cycle and gene expression of human lung adenocarcinoma A549 cells. *Journal of Xiamen University* (*Natural Science*), **2008**, 1: 104–110. https://lib.cqvip.com/Qikan/Article/Detail?id=27281406

[68] Liu, X. X., Zhang, Y. H., Li, W. H., et al. Fucoidan ameliorated dextran sulfate sodium-induced ulcerative colitis by modulating gut microbiota and bile acid metabolism. *Journal of Agricultural and Food Chemistry*, **2022**, 70: 14864–14876. https://doi.org/10.1021/acs.jafc.2c06417

[69] Yu, T., Ye, X. Y., Deng, F., et al. Protective effect of polysaccharides from *Ostrea rivularis* against reproductive injury via regulating autophagy induced by oxidative stress. *International Journal of Biological Macromolecules*, **2022**, 209: 655–667. https://doi.org/10.1016/j.ijbiomac.2022.04.053

[70] Kong, Y. Research on the Bioactivity of glycosaminoglycan from oastrea rivularis. Guangxi University, Nanning, 2020.

[71] Chen, X., Peng, L. H., Chee, S. S., et al. Nanoscaled pearl powder

accelerates wound repair and regeneration *in vitro* and *in vivo*. *Drug Development and Industrial Pharmacy*, **2019**, 45: 1009–1016. https://doi.org/10.1080/03639045.2019.1593436

[72] Li, Y. C., Chen, C. R., Young, T. H. Pearl extract enhances the migratory ability of fibroblasts in a wound healing model. *Pharmaceutical Biology*, **2013**, 51: 289–297. https://doi.org/10.3109/13880209.2012.721130

[73] Xia, M., Huang, D., Tong, Y. M., et al. Pearl powder reduces sleep disturbance stress response through regulating proteomics in a rat model of sleep deprivation. *Journal of Cellular and Molecular Medicine*, **2020**, 24: 4956–4966. https://doi.org/10.1111/jcmm.15095

[74] Zhang, J. X., Li, S. R., Yao, S., et al. Anticonvulsant and sedative–hypnotic activity screening of pearl and nacre (mother of pearl). *Journal of Ethnopharmacology*, **2016**, 181: 229–235. https://doi.org/10.1016/j.jep.2016.01.039

[75] Zhang, Z. M., Xu, Y. L, Lai, R. C., et al. Protective effect of the pearl extract from *Pinctada fucata martensii* dunker on UV‐Induced photoaging in mice. *Chemistry & Biodiversity*, **2022**, 19. https://doi.org/10.1002/cbdv.202100876

[76] Han, S. Y., Li, H. X., Lu, R., et al. Effect and mechanism of pearl on ovarian function of rats with premature ovarian failure induced by tripterygium glycosides. *Journal of Traditional and Complementary Medicine*, **2023**, 13: 368–378. https://doi.org/10.1016/j.jtcme.2023.02.004

[77] Chiu, H. F., Hsiao, S. C., Lu, Y., et al. Efficacy of protein rich pearl powder on antioxidant status in a randomized placebo-controlled trial. *Journal of Food and Drug Analysis*, **2018**, 26: 309–317. https://doi.org/10.1016/j.jfda.2017.05.010

[78] Liao, J. Separation and purification of soluble components from pearl powder and it's bioactivities. Zhejiang University, Hangzhou, 2020.

[79] Sasaki, C., Tamura, S., Tohse, R., et al. Isolation and identification of an angiotensin I-converting enzyme inhibitory peptide from pearl oyster (*Pinctada fucata*) shell protein hydrolysate. *Process Biochemistry*, **2019**, 77: 137–142. https://doi.org/10.1016/j.procbio.2018.11.017

[80] Omachi, T., Matsuyama, N., Hasegawa, Y. Nacre extract from pearl oyster suppresses LPS-induced depression and anxiety. *Journal of Functional Foods*, **2023**, 100: 105373. https://doi.org/10.1016/j.jff.2022.105373

[81] Duplat, D., Gallet, M., Berland, S., et al. The effect of molecules in mother-of-pearl on the decrease in bone resorption through the inhibition of osteoclast cathepsin K. *Biomaterials*, **2007**, 28: 4769–4778. https://doi.org/10.1016/j.biomaterials.2007.07.036

[82] Li, L., Wang, P., Hu, K., et al. PFMG1 promotes osteoblast differentiation and prevents osteoporotic bone loss. *The FASEB Journal*, **2018**, 32: 838–849. https://doi.org/10.1096/fj.201700422R

[83] Willemin, A. S., Zhang, G., Velot, E., et al. The effect of nacre extract on cord blood‐derived endothelial progenitor cells: A natural stimulus to promote angiogenesis? *Journal of Biomedical Materials Research Part A*, **2019**, 107: 1406–1413. https://doi.org/10.1002/jbm.a.36655

[84] Wang, Z. L., Liang, H. B., Guo, W., et al. Isolation, identification, and antioxidant activity of polysaccharides from the shell of abalone (*Haliotis discus hannai* Ino). *Genetics and molecular research*, **2014**, 13: 4883. https://doi.org/10.4238/2014.July.4.2

[85] Chen, C., Zhao, C. L., Wang, X. J., et al. Mechanism and effect of Shijueming (Concha Haliotidis) on serum calcium in spontaneously hypertensive rats. *Journal of Traditional Chinese Medicine*, **2013**, 33: 373–377. https://doi.org/10.1016/s0254-6272(13)60181-8

[86] Wan, C. Repairing effect of Shijueming san on ocular surface injury of dry eye model in mice. Liaoning University of Traditional Chinese Medicine, Shenyang, 2020.

[87] Chen, Z. C., Wu, S. S., Su, W. Y., et al. Anti-inflammatory and burn injury wound healing properties of the shell of Haliotis diversicolor. *BMC Complementary and Alternative Medicine*, **2016**, 16: 487. https://doi.org/10.1186/s12906-016-1473-6

[88] Du, M. Z., Li, Q., Chen, J. D., et al. Design and characterization of injectable abalone shell/calcium sulfate bone cement scaffold for bone defect repair. *Chemical Engineering Journal*, **2021**, 420: 129866. https://doi.org/10.1016/j.cej.2021.129866

[89] Cui, X. H., Zhao, X. E., Li, J. T., et al. Advances in the global distribution, chemical constituents, and pharmacology of hippocampus, a traditional marine chinese medicine. *Frontiers in Marine Science*, **2021**, 8: 774927. https://doi.org/10.3389/fmars.2021.774927

[90] Wang, C. Protective effect and mechanism of hippocampal protein on inflammatory injury of RAW2647. Harbin University of Commerce, Harbin, 2020.

[91] Di, C., Jian, C., Jian, G., et al. Evaluation of the antioxidant activity of hippocampus erectus peptides. *Food Research and Development*, **2018**, 39: 10–15. https://doi.org/10.3969/j.issn.1005-6521.2018.08.002

[92] Liu, Y. X., Li, H. Y., Yan, P. Mechanism of syngrathus protein extract underlying apoptosis of cervical cancer Hela cells. *Academic Journal of Chinese PLA Medical School*, **2014**, 35: 623–626. https://doi.org/10.3969/j.issn.2095-5227.2014.06.030

[93] Cai, X. Research progress and direction of marine mineral medicine cuttlebone. *China Journal of Traditional Chinese Medicine and Pharmacy*, **2018**, 9: 4013–4015. https://qikan.cqvip.com/Qikan/Article/Detail?id=676266479

[94] Jin, L., Ju, M., Ju, M. Determination of gastric acid content of cuttlebone. *Chinese Traditional Patent Medicine*, **2000**, 6: 66–67. https://qikan.cqvip.com/Qikan/Article/Detail?id=4340790

[95] Gao, Y., Dong, F. H., Zheng, J. Effect of sepiae endoconcha on the expression of bone healing related genes. *The Journal of Traditional Chinese Orthopedics and Traumatology*, **2004**, 16: 1–3. https://doi.org/10.3969/j.issn.1001-6015.2004.07.001

[96] Siyuan, Z., Nan, W., Jiaming, S., et al. The chemical constituents and pharmacological research of oyster in recent 10 years. *Jilin Journal of Traditional Chinese Medicine*, **2014**, 8: 821–824. https://doi.org/10.13463/j.cnki.jlzyy.2014.08.024

[97] Xu, D., Lin, F., Zhu, X. Y., et al. Immunomodulatory effect of oyster peptide on immunosuppressed mice. *Journal of Peking University* (*Health Sciences*), **2016**, 3: 392–397. https://doi.org/10.3969/j.issn.1671-167X.2016.03.003

[98] Hou, L., Wang, Q. K., He, Y. H., et al. The extraction of oyster polysaccharide and its hepatoprotective effect against alcohol-induced hepatic injury in mice. *Science and Technology of Food Industry*, **2014**, 35: 356–358,370. https://doi.org/10.13386/j.issn1002-0306.2014.22.070

[99] Kün Darbois, J. D., Libouban, H., Camprasse, G., et al. *In vivo* osseointegration and erosion of nacre screws in an animal model. *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, **2021**, 109: 780–788. https://doi.org/10.1002/jbm.b.34743

[100] Yamagami, H., Tatsuya, F., Wako, M., et al. Sulfated polysaccharide isolated from the nacre of pearl oyster improves scopolamine-induced memory impairment. *Antioxidants* (*Basel*), **2021**, 10: 505. https://doi.org/10.3390/antiox10040505

[101] Liu, S., Xiao, Y., Li, W. To research the pharmacological effects for ShiJueMing. *Journal of North Pharmacy*11, 2011, 8: 21–21+12. https://qikan.cqvip.com/Qikan/Article/Detail?id=39995854

[102] Li, H. Y., Guo, S., Yan, H., et al. Herbal textual research on Chinese herbal sargassum. *Journal of Chinese Medicinal Materials*, **2021**, 44: 1770–1776. https://doi.org/10.13863/j.issn1001-4454.2021.07.042

[103] Cai, X. Research progress and direction of marine mineral medicine cuttlebone. *China Journal of Traditional Chinese Medicine and Pharmacy*, **2018**, 33: 4013–4015. https://qikan.cqvip.com/Qikan/Article/Detail?id=676266479

[104] Zhai, R., Song, P., Ren, X., et al. Research on the ancient and modern application of marine traditional Chinese medicine endoconcha sepiae. *Chinese Journal of Marine Drugs*, **2024**, 43: 60–73. https://doi.org/10.13400/j.cnki.cjmd.2024.01.010