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Research Progress on Chemical Constituents and Pharmacological Effects of *Celosia* L.

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Abstract

Celosia L. is richly distributed in China and there are about 60 species in the world. The chemical constituents of *Celosia* L. include flavonoids, triterpenoid saponins, steroids, organic acids, and cyclic peptides. Which have a variety of effects such as antimicrobial, hepatoprotective and antitumour. To provide a scientific foundation for the subsequent phase of research and development for *Celosia* L., 30 years of pertinent global literature is summarized, analyzed, and categorized. An overview of 75 chemical constituents, pharmacological activities, and clinical applications is provided.

Keywords

Celosia L., Chemical Constituents, Pharmacological Effects

1. Introduction

Celosia L. is an annual or perennial herb, subshrub, or shrub of the *Amaranthaceae*. This genus has 60 species in total, most of which are found in subtropical and temperate regions of Africa from which the genus originated, the Americas, and Asia. In China, there are three species of *Celosia L*: *Celosia argentea* L., *Celosia cristata* L. and *Celosia taitoensis* Hayata, which are grown in the plains, field margins, hills, and slopes [1]. *Celosia argentea* L. and *Celosia cristata* L. both of which have a long history of usage as medicines in China and many ancient books record that their seeds have the effect of clearing heat and improving eyesight. Scholars both at home and abroad have conducted substantial studies on this genus in recent years. In this paper, we shall investigate *Celosia* L.'s chemical constituents and biological functions to provide literature for its further research and exploitation.

2. Main Chemical Components of *Celosia* L.

In recent decades, it has been found that the chemical constituents contained in *Celosia* L. are complex and diverse, including flavonoids, triterpenoid saponins, steroids, organic acids, and many other compounds. At present, there are 75 compounds isolated from the genus.

2.1. Flavonoids

Flavonoids, which are water-soluble phenolic compounds, are a common class of bioactive components in plants and one of the most important pharmacologically active components in traditional Chinese medicine [2]. For the first time, Li *et al.* [3] used enzymatic pretreatment to extract total flavonoids from *Celosia cristata* L. and the total flavonoids extraction rates of reflux-enzyme and ultrasound-enzyme methods could reach 94.8% and 95%. To investigate the chemical components of *Celosia cristata* L., Liu *et al.* [4] utilized ultra-performance liquid chromatography-electrospray quadrupole time-of-flight mass spectrometry (UPLC-ESI-Q-TOF-MS) and preliminarily identified 49 chemical constituents, including 17 flavonoids. A total of 18 flavonoids have been identified from *Celosia* L. in recent years [5]-[13], with specific names and structural formulae as follows (**Figure 1**).

2.2. Triterpenoid Saponin Constituents

Triterpenes are widely distributed in the form of saponins, consisting of triterpene saponin elements and sugars, glyoxylates and other organic substances [14]. *Celosia* L. is rich in saponin compounds as 24 saponins have been isolated and identified from this genus so far [8]-[20] (**Figure 2**).

2.3. Steroidal Components

Steroids are another large group of chemical constituents in the *Celosia* L., and the following five main phytosterols have been reported: *β*-sitosterol [15] [20], Stigmasterol [15] [20], Stigmast-5-en-3-ol [11], Daucosterol [11], *β*-daucosterol [16]. **Figure 3** depicts the structures of the compounds mentioned previously.

2.4. Organic Acids

Recently the organic acid components of *Celosia* L. have become the subject of research. In 2010, Chi *et al.* [6] isolated two organic acids Palmitic acid-13C, Vanillic acid from the seeds of *Celosia cristata* L. In 2011, Zhou *et al.* [11] isolated 2-hydroxyoctadecanoic acid, N-hexadecanoic acid from the seeds of *Celosia cristata* L. in 2016 Zhang *et al.* [5] isolated protocatechuic acid, 4-Hydroxybenzoic acid from *Celosia cristata* L. the specific structural formula is shown in **Figure 4**.

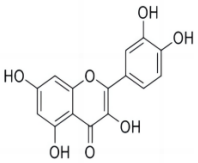
2.5. Cyclic Peptides

Plant cyclic peptides are cyclic nitrogenous compounds generated mostly by ami-

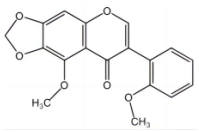
no acid peptide bonds in higher plants. They are an important class of plant metabolites as well as a class of natural small molecules with a high hit rate of lead drug discovery [20]. The cyclic peptide analogues [21]-[29] among the compounds of *Celosia* L. are shown in **Figure 5**.

2.6. Other Classes

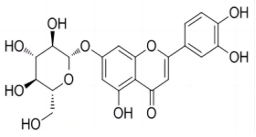
In addition to the above compounds, several other classes of compounds have



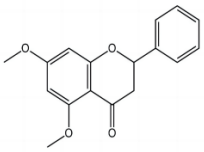
Quercetin



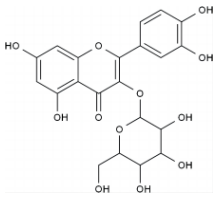
Tlatlancuayin



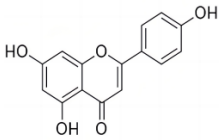
Luteolin 7-O-β-D-glucoside



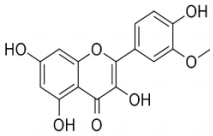
5,7-Dimethoxyflavanone



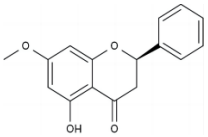
Quercetin-3-O-β-D-glucuronide



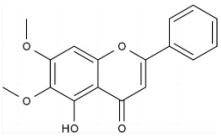
Apigenin



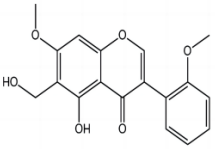
Isorhamnetin



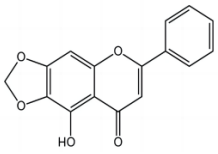
5-Hydroxy-7- methoxyflavanone



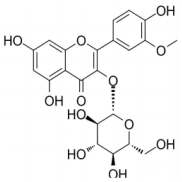
5-Hydroxy-6,7-dimethoxy-2 -phenyl-4H-chromen-4-one



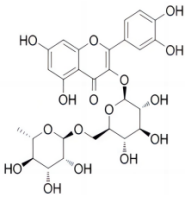
Cristatein



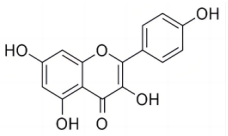
Rutin



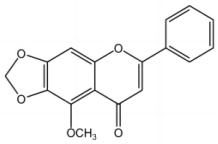
Isorhamnetin-3-O-beta-D-Glucosid



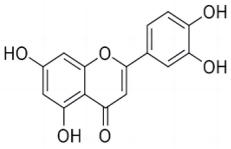
Cochliophilin A



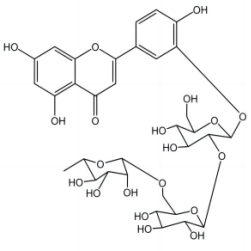
Kaempferol



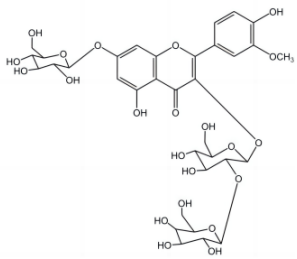
5-methoxy-6,7-methylenedioxyflavone



Luteolin

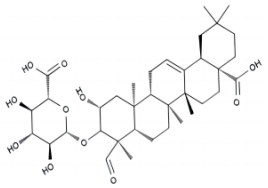


kaempferol3-O-α-L-rhamnopyranosyl-(1→6)- β-D-glucopyranosyl-(1→2)-β-D-glucopyranoside

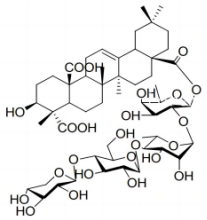


isorhamnetin3-O-(2-O-β-D-glucopyranosyl)- β-D-galactopyranoside-7-O-β-D-glucopyranoside

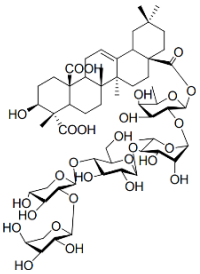
Figure 1. Flavonoids in *Celosia* L.



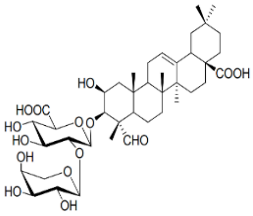
Cristatain



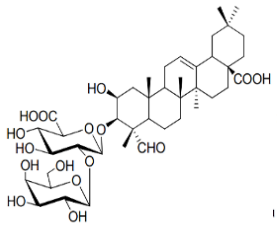
Celosin I



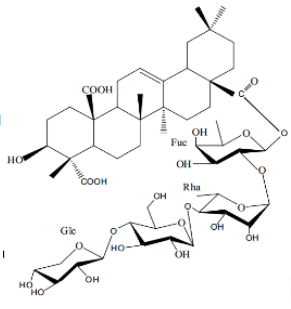
Celosin II



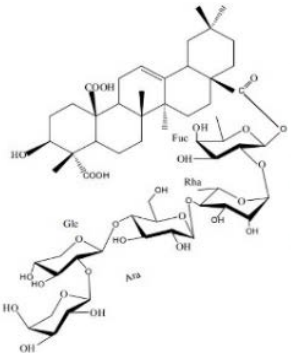
Celosin A



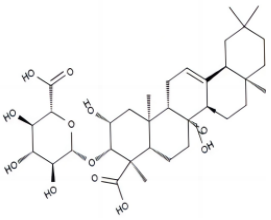
Celosin B



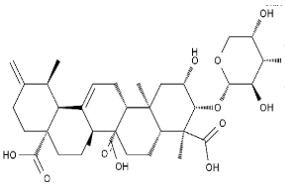
Celosin C



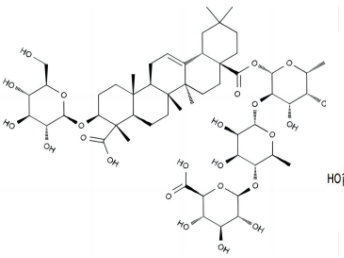
Celosin D



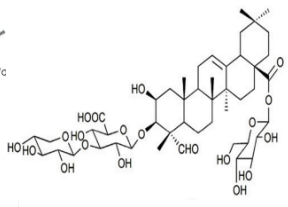
Celosin E



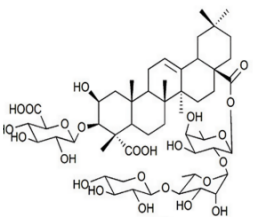
Celosin F



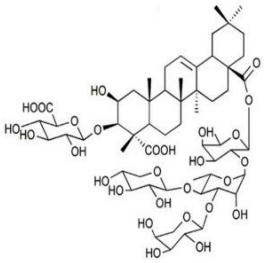
Celosin G



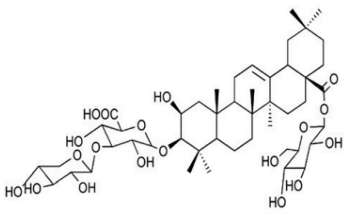
Celosin H



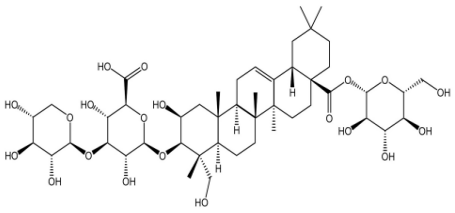
Celosin I



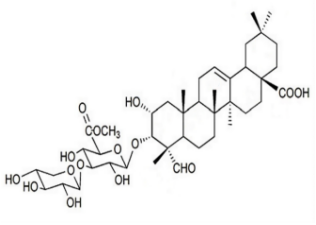
Celosin J



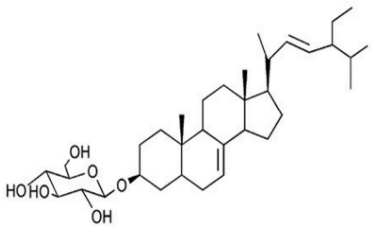
Celosin K



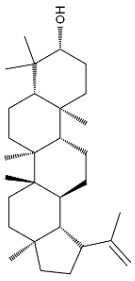
Celosin L



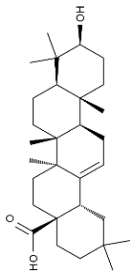
Celosin M



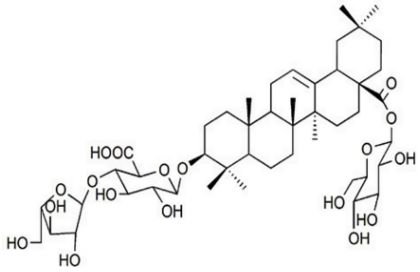
α-spinasterol-3-O-β-D-glucopyranoside



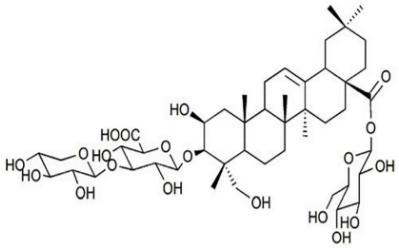
Lupeol



Oleanic acid

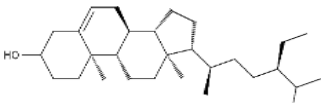


Chikusetsusaponin IV

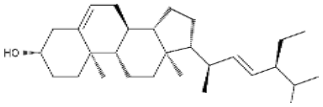


2β,23-dihydroxy-3-O-[β-D-xylopyranosyl-(1→3)-β-D-glucuronopyranosyl]-28-O-β-D-glucopyranosyl-oleano-lic acid

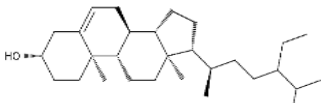
Figure 2. Triterpenoid saponins in *Celosia* L.



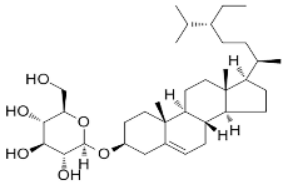
β-sitosterol



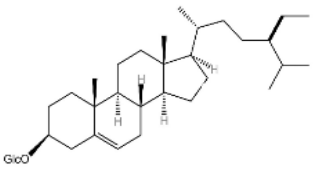
Stigmasterol



Stigmast-5-en-3-ol

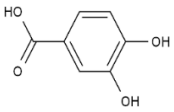


Daucosterol

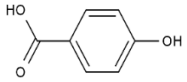


β-daucosterol

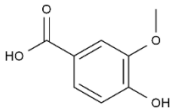
Figure 3. Steroidal compounds in *Celosia* L.



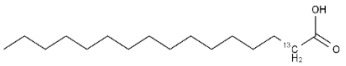
Protocatechuic acid



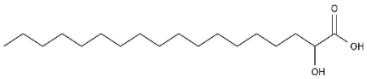
4-Hydroxybenzoic acid



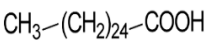
Vanillic acid



Palmitic acid-13C



2-hydroxyoctadecanoic acid



N-hexadecanoic acid

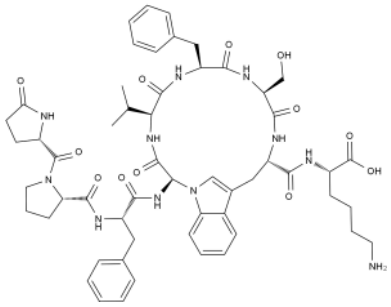
Figure 4. Organic acids in *Celosia* L.

been isolated from *Celosia argentea* L. for instance, hydroxybenzaldehydes, hydroxy-phenols, chalcone glycosides. In addition, the genus is rich in nutrients, including, proteins, dietary fibre [26], inorganic elements [27], trace elements [28], and vitamins [29].

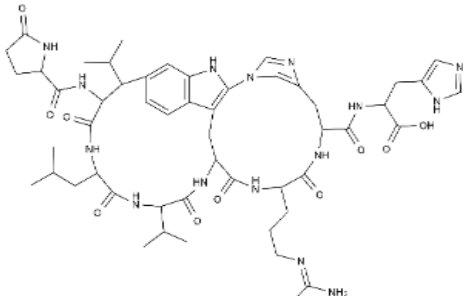
3. Pharmacological Effects in Ancient and Modern Times

3.1. Efficacy Attending Certificate

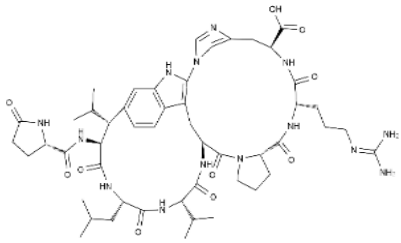
Celosia argentea L. and *Celosia cristata* L. have more records in ancient books of all ages.



Celogenamide A



Celogentin B



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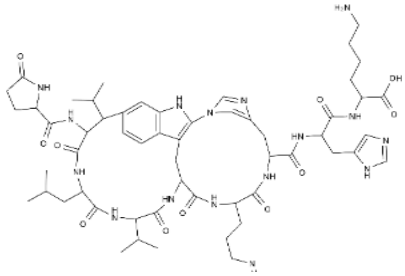
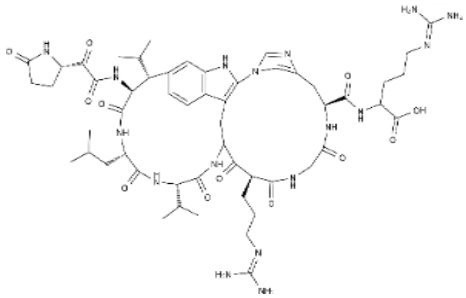
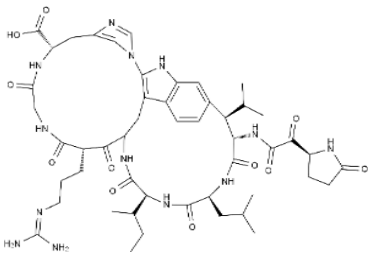


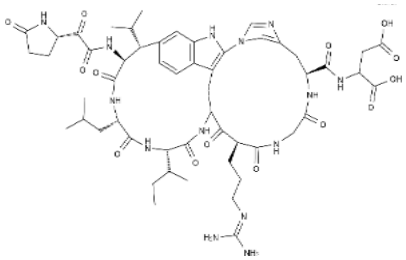
Celogentin D



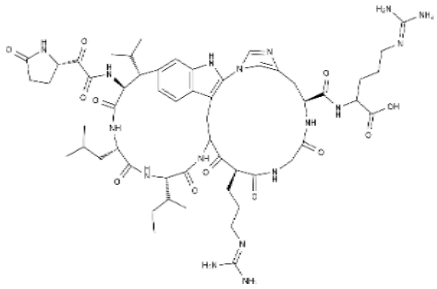
Celogentin F



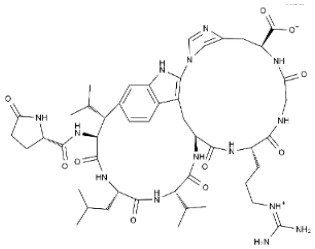
Celogentin G



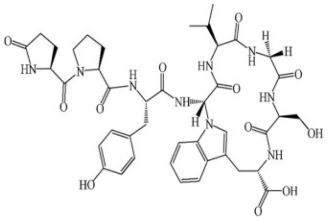
Celogentin H



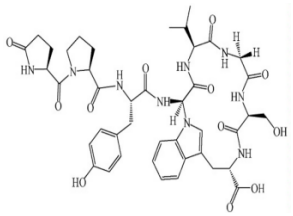
Celogentin J



Celogentin L



Moroidin



Epimer lyciumin A

Figure 5. Cyclic peptides in *Celosia* L.

Celosia argentea L. is a commonly used Chinese medicine, which has the effect of clearing liver and clearing fire, brightening eyes and removing opacity. "Medicinal Theory" said, "Bitter flat, non-toxic, treatment of liver heat poison impact eyes, red barrier, green blindness, Yi swollen" [30], "Southern Yunnan Herbal" "taste sweet bitter, bright eyes" [31]. The above records show that *Celosia argentea* L.'s bright vision is recognized by doctors of all ages.

The seeds, seedlings, flower roots and flowers of *Celosia cristata* L. can be used as medicine. It has the effect of astringent hemostasis, band stopping and dysentery stopping. Tang Dynasty "Materia Medica relics" first contained *Celosia cristata* L. seeds into medicine, said: "*Celosia cristata* L. seeds, cool, non-toxic. Stop intestinal wind diarrhea blood, red and white dysentery, women collapse in the belt under, medicine." [9] The medicinal record of *Celosia cristata* L. seedling was first seen in "Compendium of Materia Medica", Li Shizhen Yun: "Seedling: smell sweet, cool, non-toxic" [32], "Indications, sore hemorrhoids and blood disease", in the "Materia Medica primitive" [33] also has the same record. However, there are few records of the medicine of *Celosia cristata* L. root, only in the Ming Dynasty "Puji Prescription" there is "blood Yu SAN, treating blood and dirty poison, blood Yu (half two burnt ashes), *Celosia cristata* L. root, cypress leaf (one or two each) on the end" [34]. The Song Dynasty is the peak of the medicinal use of *Celosia cristata* L., "Taiping Shenghui prescription" [35] a total of "*Celosia cristata* L. powder prescription" and other 7 prescriptions used in *Celosia cristata* L., which is the earliest record of *Celosia cristata* L. medicine.

3.2. Modern Pharmacological Action

The pharmacological effects of *Celosia* L. are antibacterial, hepatoprotective, antitumour, antidiabetic, immunomodulatory.

3.2.1. Antibacterial Effect

Wiart *et al.* [36] studied the antimicrobial activity of 50 traditional plants and showed that the ethanolic extract of *Celosia argentea* L. possessed significant antimicrobial activity, with strong inhibitory effects against Bacillus cereus, Candida albicans, Pseudomonas aeruginosa and Staphylococcus aureus. Su Baoshun *et al.* [37] used reflux extraction method to extract the active ingredients from different parts of *Celosia argentea* L. and carried out in vitro bacteriostatic activity experiments using its agar plate twofold dilution method. The results showed that the diameter of MRSA and Staphylococcus aureus were (25.9 ± 0.2) mm and (21.6 ± 0.5) mm respectively, and the bacteriostatic properties were stable under ultraviolet irradiation, but the bacteriostatic effects were significantly worse at 121˚C, and high temperature treatment should be avoided.

3.2.2. Hepatoprotective Effects

Li *et al.* [38] observed the therapeutic effect of *Celosia argentea* L. Celosin A in the model of acute haemorrhagic necrotizing pancreatitis (AHNP) induced by sodium taurocholate in rats. Celosin A significantly reduced the amount of ascites, serum amylase content, TNF-α content and NF-κB protein expression in

the liver tissues of the rats. Celosin A was shown to have a strong protective effect against AHNP-induced hepatic damage. Wang *et al.* [39] showed that a new compound, Cristatain from *Celosia argentea* L. may cause the protective effect against AHNP-induced hepatic damage, Wang *et al.* examined the preventive effects of various dosages of Cristatain against mice with liver damage caused by carbon tetrachloride. The findings revealed that Cristatain had a significant protective effect against liver injury as evidenced by the levels of aspartate aminotransferase, alanine aminotransferase, and alkaline phosphatase in serum and histopathological examinations being significantly lower than those in the control group.

3.2.3. Anti-Tumour Effects

Wu [40] studied the chemical components of *Celosia argentea* L. in vitro for antitumor efficacy which showed that Celosin A and Celosin B had good antitumour activity on five types of tumour cells (human glioma cells, human intestinal cancer cells, human leukaemia cells, human breast cancer cells and human hepatocellular carcinoma cells). Jiang [41] established the S180 solid tumour model by instilling the model mice with *Celosia cristata* L. preparation. When hormonal mass was compared between the experimental and control groups of preparations, it was discovered that the weights of the thymus and spleen in the experimental group were larger than those of the control group.

3.2.4. Antidiabetic Effect

Guo *et al.* [42] administered a flavonoid extract of *Celosia argentea* L. by gavage to diabetic mice and discovered that, when compared to the model group, the administered mice's body mass increased, but their splenic weight index decreased significantly, and their mononuclear macrophage phagocytosis of chicken erythrocytes decreased. In the process of diabetes mellitus, macrophages accumulate and phagocytose normal cells in large quantities, and the flavonoid extract of C. chinensis can reduce the phagocytosis of macrophages in the organism, thus achieving the purpose of preventing and controlling diabetes mellitus.

3.2.5. Immunomodulatory Effects

HaseK *et al.* [43] demonstrated that *Celosia argentea* L. glycoside may increase the generation of tumor necrosis factor in mice as well as the synthesis of interleukin-1 and nitric oxide by macrophage J774.1 in a dose-dependent way. Zhang [44] used a xylene-induced mouse ear swelling model and an acetic acid-induced mouse peritoneal capillary permeability paradigm to inject different doses of *Celosia argentea* L. n-butanol extract into the model mice. The results showed that the inhibition rate of the high-dose group of *Celosia cristata* L. n-butanol extract was 2 - 3 times that of the low and medium doses. This confirmed the anti-inflammatory effect of n-butanol extract of *Celosia cristata* L.

3.2.6. Anti-Cardiovascular Effects

Li [45] *et al.* administered a high-fat diet to a rat model of atherosclerosis before

supplementing with *Celosia cristata* L. extract. When rats were compared to a high-fat control group, TC, aortic wall malondialdehyde (MDA), and serum LDH levels were dramatically reduced, whereas erythrocyte SOD levels were significantly enhanced. It also dramatically increased serum copper and zinc levels in rats while decreasing serum copper/zinc ratio and affecting serum calcium. It was discovered that *C. henselae* had an antagonistic effect on the rise in serum Cu/Zn ratio caused by a high fat diet. Cu is a major active component of SOD in rat erythrocytes, and increasing SOD value is beneficial for scavenging free radicals. As a result, *C. henselae*'s anti-atherosclerotic action is linked to its modifying effect on serum Cu, Zn, and Ca levels.

In addition to the pharmacological effects listed above, *Celosia* L. also has haemostatic [46], analgesic [47], protection against oxidative damage to the lens [46], prevention of osteoporosis [21], anti-aging [48], neuroprotection [48], and enhancement of body tolerance [48].

4. Conclusions

As of July 2023, a total of 75 compounds have been isolated from *Celosia* L. including 18 flavonoids, 21 triterpenoid saponins, 5 steroids, 6 organic acids, 11 cyclic peptides, and 14 others., Clearly, flavonoids and triterpenoid saponins are the most dominant chemical constituents in this genus.

According to the literature, *Celosia* L. has many species and wide distribution, among which *Celosia argentea* L. and *Celosia cristata* L. are both Chinese herbal medicines recorded in the 2020 edition of the Chinese Pharmacopoeia, which have considerable medicinal value. The most researched plants in *Celosia* L. are *Celosia argentea* L. and *Celosia cristata* L., while there are few domestic and international literature reports on *Celosia* taitoensis. This indicates that *Celosia* L., especially *Celosia taitoensis* Hayata, is in urgent need of research and development. Corresponding pharmacological studies have shown that the extracts and compounds of *Celosia* L. have antibacterial, hepatoprotective, antitumour and antidiabetic effects, which provide a basis for the further development and *Celosia* L. medicinal resources and an essential reference for the research and production of numerous sorts of novel medications.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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