Research on the Reuse of Licorice Residue

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Abstract. In order to realize the transformation of licorice residue into treasure and promote the sustainable development of Chinese medicine, this paper reviews the history, current situation and development prospect of the utilization of licorice residue, and on the basis of understanding the overview of the utilization of licorice residue, explores the innovative points of the research on the utilization of licorice residue and provides countermeasures for its future development. Glycyrrhiza glabra is widely used in all kinds of prescriptions and has been consumed in considerable quantities in both ancient and modern times. Ancient people did not make full use of liquorice residues, but today, with the great development of science and technology, people have a better understanding of it. Licorice residues contain a variety of chemical components that exhibit different biological activities and have great potential for application. Once extracted, these components can be used in the fields of medicine and chemicals. However, the utilisation of liquorice residues still suffers from low utilisation rate, immature technology and low extraction of target active ingredients. In the future, researchers can further develop the resources of liquorice residue from the perspectives of extending the efficacy, studying the components in depth, optimising the instrumentation and extraction process.

Keywords: licorice residue; Reuse; Current status of research.

1. Introduction

After the "double carbon" target was put forward, all industries are seeking their own green development path. The total amount of Chinese medicine residue produced each year is very large and complex to manage, with low utilisation rate but the active ingredients in it have high economic benefits. Therefore, the pollution, treatment and reuse of Chinese medicine residues have become a major challenge to the green development of the Chinese medicine industry in China. At present, the main reuse of dregs is mainly as feed or organic fertilizer without high added value, and only accounts for 1% of the total dregs, and most of the rest is piled up in fields, mountains, and other remote areas, which are prone to decay and odour after the wind and sun, and are easily harmful to the natural environment when they penetrate into the soil or flow into rivers, and are also an important resistance to China's efforts to strengthen ecological protection and resolutely fight the battle against environmental pollution. For example, there are still about 30% of flavonoids in liquorice residue still to be extracted, so the extraction and reuse of residue is a huge treasure trove worthy of our in-depth study. In this paper, we discuss the contrast between the huge consumption of liquorice and its reuse, the current situation of the use of liquorice residues and the prospects for the development of research on the use of liquorice residues, the directions in which innovation can be developed and the current plans and outlook.

2. Historical development of the use of liquorice residues

2.1 Huge consumption of liquorice residues

Licorice has been used as a very important herbal remedy since ancient times. In ancient times it was known as "nine herbs in ten prescriptions", and as early as the Southern Dynasty it was known as the "king of all medicines", and was mentioned in the "Fifty-two Prescriptions for Diseases" and the "Compendium of Materia Medica". In the Treatise on Typhoid Fever, 62.5% of the total number of prescriptions contain Glycyrrhiza glabra and 36.6% of the total number of prescriptions in the Jin Kui Yao, and in the hands of folk practitioners it is commonly used, which shows its huge consumption. In recent times, with the introduction of western medicine and its new use of licorice, the production of some Chinese patent medicines and the deep processing of licorice in which the nutrients are extracted, has increased the annual consumption of licorice even more. Its consumption has been rising in recent years, with the market size growing from 1.814 billion yuan in 2016 to 3.137 billion yuan in 2021, further increasing its consumption.

2.2 The use of ancient liquorice residues

In the ancient times, no separate use was made of the dregs of liquorice, but there are records of the use of the dregs as a whole. As early as the Han Dynasty, in a medicine book excavated at Mawangdui, it was recorded that the physician would put the used dregs of the medicine into a coarse cloth and boil it again with water to make a medicine towel to put on the patient as a medical treatment. Other than this, the dregs were mostly discarded or used as fodder and there was no other way to use them.

2.3 Modern use of liquorice residues

In modern times, the overall use of the residues, such as composting technology, mixed combustion technology and biogas digester fermentation technology, has generally been put to good practical use. In addition, there are new ways to utilise separately separated liquorice residues, which have been found to be of high value with a total flavonoid content of up to 30% and a wide range of biological activities.

2.4 Huge comparison between the amount of liquorice residue utilised and the amount generated

The use of liquorice continues to grow and with it the problem of disposal of its residues. The current disposal method is simple landfill incineration and not much is actually used. In 2021 statistics, for example, only 1% of the residue produced was used for resource purposes, making it an extremely valuable renewable resource.

3. Analysis of the current situation of the utilization of licorice residue

3.1 Distribution of licorice in prescriptions

Glycyrrhiza glabra is known as the "national old man" and is most frequently used in all kinds of prescriptions, with a variety of effects. Liu Guomei et al.[1] used various editions of prescription textbooks as a model, and based on literature review and clinical practice, integrated and analyzed that licorice was used in almost all kinds of prescriptions, but the proportion varied, with 84.78% in antiphlogistic agents and 77.27% in antiphlogistic agents, while the proportion in anthelmintic and gushing agents tended to be close to zero, which was influenced by both the functions of licorice and the main treatment of prescriptions.

3.2 Pharmacological studies of liquorice residues

Qualitative analysis of the organic fractions in liquorice residues revealed the presence of sugars, flavonoids, steroids, amino acids, triterpenes, coumarins and organic acids [2].

3.2.1 Glycerol residue extracts

You Xiulan[3] The growth of moulds and yeasts was shown to be inhibited by liquorice residue extracts, thus providing a preservative effect. The inhibitory effect on yeast must be shown in a certain pH range, and the inhibitory activity is stronger in acidic media, and the inhibitory effect is positively correlated with the concentration of licorice residue extract.

3.2.2 Glycyrrhiza glabra residue polysaccharide

Wang Yuewu et al.[4] Animal experiments on S-180 and Ehrlich's ascites tumor indicated that the gibberellin polysaccharide in licorice pomace had the strongest inhibitory effect on S-180 and Ehrlich's ascites tumor within a certain dose range. Among them, the inhibition rate of S-180 could be as high as 80%, and the inhibition rate of Ehrlich ascites tumor was over 30%. The inhibition of S-180 and Ehrlich's ascites tumour was more than 30%. The effect of GPS on male mice was gender-specific.

3.2.3 Flavonoids from liquorice residues

Licorice residue contains a variety of active ingredients, including flavonoids that can lower blood sugar, as well as anti-ulcer, antispasmodic and antioxidant, and its effect on scavenging free radicals is significantly better than other substances [5].

In recent years, researchers have identified estrogenic flavonoids known as licorice flavonoids, which can be divided into several different types, of which licorice chalcone A and licorice chalcone E have great potential for development. Chalcone A is a specific substance found in licorice with the highest content of its kind [6]. Its anti-inflammatory, antibacterial, hypolipidemic and antiparasitic properties have wide potential for development in the medical field [7].

Photoglycyrrhizidine is a flavonoid with a wide range of uses in liquorice residues [8]. It is a specific substance found in Glycyrrhiza glabra, and its content ranges from 0.1% to 0.3%. In addition, extensive pharmacological experiments have been carried out on Glycyrrhizin, which has been found to prevent diseases such as atherosclerosis and cellular ageing by inhibiting the production of free radicals by P450/NADPH in cells [9]. It is a class of antibacterial substances [10], which also regulate immunity and inhibit melanin production.

3.3 Licorice residue extraction process

3.3.1 Extraction of glycyrrhetinic acid and polysaccharides

Zu Yuan Gang et al.[11] applied ultrasonic extraction technique and experimentally indicated that 1.45% of glycyrrhetinic acid could be obtained from licorice residue under supercritical conditions. Li Bingqi et al.[12] applied ultrasonication combined with alcohol extraction to obtain 2.3% of polysaccharides and 6.6% of glycyrrhetinic acid after 75 min at 45°C and solid-liquid (1:1) conditions.

3.3.2 Extraction of total flavonoids

Zhang Zhidong et al.[13] Extraction of 2.3% of total flavonoids was carried out using alcohol extraction of liquorice residues at pH 6.0 and 55°C after the addition of cellulase 50 U/ml and pectinase 100 U/ml in combination for 120 min. Wang Yun Yun et al.[14] used solid fermentation method to increase the extraction of total flavonoids by fermentation of Aspergillus niger strain for three days under the conditions of licorice residue-bran (6:4), inoculum level of 6.0% and 1.2 times of initial moisture content.

3.3.3 Extraction of Chalcone A

Zhang Juan et al.[15] prepared chalcone A and purified it by refluxing the ethanol solution, two extracts were performed successively 1 h apart and the two extracts were mixed to make the upper

sample solution. The upper sample was passed through XDA-1 macroporous resin at 1.5 Bv/h, where 2 Bv of 35% ethanol solution was used to elute the upper sample to remove impurities, followed by further elution with 6 Bv of 90% ethanol, after which the eluate was collected and concentrated until alcohol-free. Three extractions were carried out under the condition of water-ethyl acetate (1:1), and finally the ethyl acetate extracted layers were combined and evaporated to dryness. 38 g of ethyl acetate was dissolved in an appropriate amount of methanol, mixed with silica gel and then separated on silica gel chromatography. The gradient elution was carried out under petroleum ether-acetone (10:1, 8:1, 6:1, 4:1) conditions, and the eluate was collected by thin layer chromatography for identification, and then evaporated by rotation at 40℃ to a golden yellow consistency. Recrystallization was carried out under petroleum ether-ethyl acetate (1:1) conditions, and finally 4.1 g of glycyrrhiza chalcone A was obtained by rotary evaporation at 45℃ in a yield of 3.56 mg/g.

3.3.4 Extraction of photoglycyrrhizidine

Zhu Hui et al. [16] concluded that the light glycyrrhizin extraction process can be divided into two categories: traditional and modern. Among them, the traditional extraction processes are represented by organic solvent extraction method and hot water extraction method. The former is based on the difference of solubility of each component in organic solvents and selects the appropriate solvent for extraction, which is inexpensive and can also yield more kohligandine, but will cause a certain degree of environmental pollution. The latter direct decoction with water to obtain an aqueous extract containing phloroglucuronide is a simple, low-cost and environmentally friendly operation, but subsequent treatment becomes a major challenge. Modern extraction processes mainly include ultra-high pressure extraction, ultrasonic extraction and ion extraction, etc. The above techniques have resulted in higher yields of hwanganganoderma and are also more environmentally friendly. Wang Hongpeng et al. [17] investigated the optimal conditions for supercritical diCO2 extraction by controlling single factors such as extraction temperature, extraction pressure and extraction time, and finally pointed out that 45 ℃, 25 MPa and 60 min static extraction could yield 0.009% of hwanganganoderma.

3.4 Recycling of liquorice residues

The residue left after the extraction of licorice is often treated as waste, and achieving the integrated use of the waste contributes to the sustainable development of the TCM industry. Wu Hua et al. [18] added liquorice residues to the feed of chickens and showed that the addition of 4% of liquorice residues could improve the quality of broiler chickens by improving carcasses. The flavonoids extracted from liquorice residues are very similar in structure to those contained in licorice and have the same activity, which can be applied in medical fields such as antibacterial, anti-HIV, anti-ulcer, liver protection and hypoglycaemia after reuse. The medicinal and economic value of liquorice residue needs to be further developed. If the disposal of the residue can be effectively solved and its potential resource advantages can be fully utilised, both ecological and economic benefits can be realised.

4. Future prospects for the use of liquorice residue

4.1 There are clear deficiencies in the current situation

4.1.1 Low utilisation of liquorice residues

The dregs produced by using boiled Chinese herbs have a high water content and are easily perishable. For a long time, pharmaceutical companies usually use processes such as water extraction, ethanol extraction and alkali extraction to extract glycyrrhetinic acid, the main medicinal component of licorice, and the residue after extraction is usually discarded. The existing disposal methods in China are still stockpiling, incineration and landfill. These crude and low-value disposal methods are costly and also cause waste of resources and environmental pollution.

In recent years, the development and utilisation of liquorice resources in China has deepened, the demand for liquorice and its products has grown and resources have been drastically reduced. At the same time, the residue left after the extraction of liquorice is gradually turning into another ecologically harmful substance. At present, it is known from research that the utilisation rate of liquorice residue is only about 30%.

It is estimated that tens of thousands of licorice residues are not utilized resourcefully in China every year [19], but it is a very valuable reusable resource. Therefore, how to extract the active ingredients from licorice residues again is of great practical significance for the full development and utilization of licorice residues.

4.1.2 Complex composition of licorice residue, difficult to develop technology

The main reason for this is that its composition is complex and the content and mechanism of action of its active ingredients are still unclear and need to be researched; the quality of the drug source, its content and the stability of the preparation itself have been troubling people; when it comes to the extraction of the active ingredients of liquorice residues and their application in mass production, the machinery and equipment are expensive and it is difficult to develop mature technology.

Liquorice residues are regarded as a valuable and promising reusable resource. Currently, research on this subject is incomplete. Further clarification of its chemical composition and pharmacological effects, the establishment of a new method for rapid, accurate and efficient multi-component analysis, and enhanced use awareness and exploration of optimal extraction processes will facilitate the progress of research on the reuse of liquorice residues as a whole, which in turn will attract attention and realise real benefits.

4.1.3 Single treatment method for dregs, less extraction of target active ingredients

Due to the rigid target of drug safety, the preparation process of licorice formulations and no-punch formula granules is mainly water decoction, which leads to a high residual of fat-soluble flavonoids and some low-polarity available components in the residue. The response surface optimization of supercritical CO_2 extraction and the separation of organic solvents such as esters, ethers and alcohols is still under development.

Some groups have suggested that cellulase could be used to promote the breakdown of cellulose cell walls, thereby facilitating the release of residual active substances, and that the chemical composition of the enzymatic digestion could be studied quantitatively and qualitatively for rationalisation. Although theoretically feasible, this technology has not yet been carried out on a large scale due to cost and equipment problems.

4.2 Research on the use of liquorice residues can be innovative

4.2.1 Enzymatic extraction method

Flavonoids in liquorice can be converted into glycyrrhizin under the action of specific enzymes. Glycyrrhizin has pharmacological effects such as hepatoprotective, anti-inflammatory and anti-tumour, and it has broad application prospects in the fields of Chinese medicine, cosmetics and health food. The extraction of glycyrrhizin by enzymatic conversion is inexpensive and environmentally friendly, and is a new idea that is more easily accepted by society and enterprises [20].

4.2.2 Antitumor effect of licorice residue extract

Han Yongzhe [21] et al. found that the tumour-inhibiting effect of total flavonoids in licorice residue was significantly higher than that of total flavonoids in liquorice. By comparing the chemical composition of the two, it was concluded that the content of chalcone A in the total flavonoids of licorice residue was greatly increased and was the most characteristic component.

His group's research also clarified that licorice residue is a potential resource for anti-tumour drugs. The total flavonoids in licorice residue are characterized by clear main components, high flavonoid content and low price. Its mechanism of action is to induce early apoptosis of tumour cells. Therefore,

total flavonoids from licorice residues are expected to become an important source of pure natural antitumour drugs.

4.2.3 Preservation and sterilisation of liquorice pomace extracts

Most of the small organic molecules are hydrophobic and act on the cell membranes of microorganisms, even dissolving them and thus inhibiting or killing them.[22] . The basic principle of its preservation is therefore to inhibit the microbial activity on the surface of the fruit and to reduce its impact on the fruit, thus reducing its physiological activity.

Chinese medicine extraction technology is non-toxic, residue-free, non-toxic and extremely rich in Chinese plant resources, so its use for preserving and preserving fruits and vegetables has broad application prospects.

4.2.4 Antioxidant effect of licorice pomace extract

Glycyrrhiza glabra residues contain flavonoids which have a strong antioxidant effect. However, current research has mainly focused on the crude extracts of the plant and light glycyrrhizin. In fact, in addition to these components, liquorice pomace also contains a number of other types, including dihydroflavones, isoflavones and chalcones, and they are also likely to have better antioxidant activity from a constitutive relationship point of view.

4.3 Countermeasures for the development of liquorice residues

4.3.1 Extending the efficacy of licorice residue applications

Liquorice residue has great advantages in the treatment of western medical diseases, such as antibacterial and antimicrobial, immune enhancement, anti-HIV, anti-tumour ulcer, liver protection and sugar reduction. Adding its extract to beverages, sweets and other foods can improve the body's nutrition and fitness; making toothpaste and toiletries are great air cleaners; and using it in cosmetics has antioxidant and age-delaying properties. These studies and new discoveries have brought the application of liquorice residues to a new level, so it is imperative to study new functions of liquorice residues to better serve the health of the people.

4.3.2 In-depth study of the components of liquorice residues

One of the main components of licorice residues is fat-soluble flavonoid glycosides, which have various structural types and vary greatly in activity. However, the variety of compounds obtained from the current experiments is insufficient and the screening of antioxidant activity is not comprehensive enough to reflect the activity of flavonoid components. In order to further develop the use of licorice residue, in-depth research on its chemical composition and computer-aided drug design, combined with multiple in vivo and out vivo indicators to systematically evaluate the activity of active ingredients, will be beneficial to the development of the refined use of licorice residue [23].

4.3.3 Optimisation of instrumentation and extraction process

The active ingredients of licorice residues obtained through extraction usually have high pharmacological activity, but there are also some ingredients with low pharmacological activity. Therefore, in the production of traditional Chinese medicine, it is necessary to strengthen the research on the extraction process of traditional Chinese medicine and the optimal design of equipment, as well as the adoption of advanced equipment and technology, in order to improve the homogeneity, quality stability and efficacy of traditional Chinese medicine, so as to promote traditional Chinese medicine to the world and enhance its international competitiveness [24].

5. Conclusion

With the booming development of Chinese medicine in China, the industrialization of Chinese medicine resources has resulted in an increasing amount of waste from Chinese herbal medicine, and the problem of how to make full use of the residue of licorice and bring it to its proper value needs to

be solved. It is hoped that this review will have some significance for the resource utilization of licorice residue and establish the circular economy concept of "production-use-recycling-resource" to promote the sustainable development of Chinese medicine in China. This paper is a comprehensive study on the resource utilization of sweet dregs. Due to the limited level, there may be some academic problems in this paper, but in the future, the reuse of licorice residue extract is still an important topic and research direction. Improving the resource utilisation efficiency of liquorice residue can not only save resources and energy, extend the resource economy industry chain, but also reduce emissions and pollution to the ecological environment. Therefore, it is of great social and economic benefit to clarify the value of using liquorice residue and to conduct research on its resourceful reuse. The analysis and treatment of licorice residue from multiple aspects and ways to improve its recycling value and maximize the recycling of Chinese medicine boiling waste is the direction we should work on at present.

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