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Using Fermented Astragalus Membranaceus Residue to Produce Functional Feed

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Abstract: The Chinese Ministry of Agriculture and Rural Affairs issued Announcement No. 194, stipulating that "starting from January 1, 2020, all growth-promoting drugs except traditional Chinese medicine shall be phased out as feed additives; starting from July 1, 2020, feed production companies shall cease the production of commercial feed containing growth-promoting drug additives (excluding traditional Chinese medicine)". The development of alternative antibiotic feed additives has become a hot topic in the livestock industry. In this study, the residues produced in the production process of Astragalus formula particles was used as raw material, and probiotics for feed additives were selected for solid fermentation, select the best fermentation strains and optimize the fermentation process; detect different analytical methods of fermentation products, nutritional components and safety and health conditions through in vitro experiments. Through the above research, it aims to provide a basis for the research and development of dietary antibiotic substitutes and traditional Chinese medicine residue resources.

Keywords: Astragalus Membranaceus Residue; Solid-state Fermentation; Substitutes for Antibiotics; Feed Additives; Probiotics.

1. Foreword

With the rapid development of traditional Chinese medicine (TCM) in China, the amount of TCM waste residues is increasing. Traditional methods of handling TCM waste include incineration and landfilling, which not only increase production costs but also lead to serious pollution [1]. However, TCM waste residues are not devoid of value. After the extraction of active ingredients through decoction, the remaining TCM waste still retains medicinal properties and can be used for preventing and treating animal diseases [2]. Directly using TCM waste as feed additives has certain limitations, such as the ineffective absorption of active components and nutrients by animals and the requirement for large quantities in feed formulations [3]. Research has shown that biological fermentation is the most promising processing technique for developing and utilizing TCM waste-based feed.

2. Research Progress on Chinese Medicine Residues

2.1. Used for Livestock and Poultry Feed

The residual medicinal ingredients in Chinese medicinal residues, such as polysaccharides, flavonoids, saponins, as well as nutrients like proteins, crude fats, amino acids, etc., can enhance the immune system, regulate nutrition, and improve meat quality in animals. They can be used as feed additives for livestock and poultry [4]. Chinese medicinal residues can be used as feed additives through direct pulverization or biofermentation transformation [5].

Shao Shujuan et al. found that adding 3% of Chinese medicinal residues at four different growth stages of pigs significantly reduced the odor in the pigsty, indicating that adding Chinese medicinal residues to the diet can reduce pig manure emissions and protect the environment[6]. Li Zhengqiu et al. conducted a study and found that using Chinese medicinal residues as the main ingredient in the diet for Huzhou sheep can effectively reduce feeding costs and improve the economic benefits of Huzhou sheep farming[7]. Li Yuhua et al. studied the effects of different Chinese medicinal residues on the growth performance and blood biochemical parameters of beef cattle and found that adding an appropriate amount of Chinese medicinal residues to the diet can effectively increase the average daily weight gain and growth rate of beef cattle, as well as enhance their immune capacity[8]. Qu Honglei et al. discovered that the compound gelatin residue can replace coarse fodder for feeding donkeys[9]. It can improve the metabolic function of the body by enhancing metabolic enzymes and organ indices. Li Yanjun et al. found that adding 2% to 3% of Xiangzhengqi medicinal residues to the basic diet can improve the lactation performance of lactating Rex rabbits by increasing milk production and weaning weight, as well as promoting the growth and development of the offspring[10].

Li Huawei et al. conducted a study on the effects of adding Chinese medicinal residues and fermented Chinese medicinal residue preparations to the feed of sows and piglets[11]. They found that the addition of fermented Chinese medicinal residues had a better effect on promoting growth and development. Li Hualei et al. found that the fermented Chinese medicinal residue of their self-prepared "Shiquan Dabu" formulation met the national feed safety standards[12]. Feeding it to weaned piglets significantly improved their growth performance and antioxidant capacity, reduced diarrhea incidence, and enhanced humoral immunity. Xie Peifeng et al. found that adding 0.5% fermented Chinese medicinal residue extract to the perinatal diet of sows benefited the intestinal health of the sows. Nie Ming et al. found that adding 3% fermented Chinese medicinal residue filtrate to the basic diet of broiler chickens could replace antibiotics as a feed additive, resulting in improved production performance, increased immune organ index, and balanced intestinal microecology [13].

2.2. Used for the Preparation of Organic Fertilizers

In Chinese medicinal residues, the remains are mostly plant-based components that are lightweight and have good air permeability. They also contain various trace elements and organic matter required by the soil, making them suitable for the preparation of ecological organic fertilizers [14]. In the production process, composting techniques are commonly employed to convert Chinese medicinal residues into humus through microbial activity [15]. Zhao Chengpeng et al. found that composting medicinal residues of heat-clearing and detoxifying herbs could be used to improve soda saline-alkali soil conditions[16]. In practical application, the appropriate dosage of composted materials is typically controlled at around 3%.

Experimental studies conducted by Chen Fen et al. revealed that bio-organic fertilizer made from Chinese medicinal residues effectively improves soil heavy metal pollution and enhances soil fertility, making it suitable for application in slightly acidic soils in southern regions[17]. Research by Zhou Zengyan et al. concluded that co-composting of livestock manure and Chinese medicinal residues accelerates the composting process and enhances humification[18]. Meanwhile, Jin Qian et al. found that composting Chinese medicinal residues promotes earthworm growth, with the optimal conditions occurring at around 25°C[19].

3. Research Progress on Probiotic Fermentation of Chinese Medicinal Residues

3.1. Commonly Used Probiotic Strains for Fermenting Chinese Medicinal Residues

Lactic acid bacteria are a type of beneficial microorganisms that ferment carbohydrates and produce lactic acid as their primary end product. They typically thrive under microaerobic conditions[20]. Commonly used genera of lactic acid bacteria include Lactobacillus, Bifidobacterium, Streptococcus, Leuconostoc, and Pediococcus, among others. Lactic acid bacteria used as commercial fermentation agents possess various metabolic characteristics such as acidification activity, protein hydrolysis activity, antagonistic activity, and the ability to produce exopolysaccharides[21]. Due to the beneficial effects of lactic acid bacteria on nutrition and health in humans and animals, there is a growing interest in their application in food and feed.

Studies have found that lactic acid bacteria have a "generally recognized as safe" status and play a role in regulating the immune system, enhancing intestinal metabolic capabilities, and maintaining intestinal microbial balance in animals[22]. Research by Zhang Lianzhong has shown that adding plant-derived Lactobacillus to the daily diet can reduce the inhibitory effect of Escherichia coli on the growth performance of weaned piglets, thus improving the intestinal microecological environment[23]. Lactic acid bacteria have higher requirements for temperature, humidity, and oxygen concentration in the environment. The viability of live bacteria significantly decreases at room temperature, making it a research focus in various industries and scientific fields[24].

3.2. Fermentation Process for Medicinal Herb Residues

3.2.1. Liquid Fermentation

Liquid fermentation, also known as submerged fermentation, is a development based on the production process of antibiotics. It involves adding fermentation strains into a liquid medium, mixing them, and fermenting at an appropriate temperature. The resulting products include mycelium and fermentation broth [25]. Research has found several advantages of liquid fermentation, including fast fermentation speed, short production cycle, high level of mechanization and automation, easy control of process parameters, and strong reproducibility of microbial propagation [26].

3.2.2. Solid-state Fermentation

solid-state fermentation refers to the growth and biological reaction process of microorganisms on a substrate with little or no freely flowing water. The technology of solid-state fermentation originated from the production of koji and brewing in China. In the late 1980s, Professor Zhuang Yi from Nanjing University of Chinese Medicine proposed the "bi-directional fermentation" theory for medicinal fungi. He believed that bi-directional solid-state fermentation technology is the most promising approach for the development of pharmaceutical residues. The advantages of solid-state fermentation include high product quality and activity, simple production process, low investment, and minimal waste and pollution [27].

3.3. Advantages of Probiotic Fermentation of Chinese Medicinal Residues

3.3.1. Production of New Bioactive Compounds

In the process of probiotic fermentation of medicinal residues, certain components in the residues may have either promoting or inhibitory effects on the growth and metabolism of probiotic bacteria. Under specific environmental conditions, the medicinal residues and probiotic bacteria can also undergo modifications in their metabolic pathways, leading to the generation of diverse metabolites and the production of new bioactive compounds. Li Guohong et al. used Bacillus subtilis to ferment the roots of Panax notoginseng and isolated Rh4, a ginsenoside transformed by Bacillus subtilis, from the fermented saponins of Panax notoginseng[28]. This compound was not detected before fermentation, indicating that it was newly produced through microbial fermentation.

3.3.2. Reducing the Toxic and Side Effects of Medicinal Residues

The decomposing and transforming effects of probiotic bacteria can potentially break down and convert certain toxic components in medicinal residues, such as alkaloids, glycosides, heavy metals, etc. Alternatively, they can chemically modify the toxic components in medicinal residues to achieve the goal of reducing the toxic and side effects of medicinal residues. He Luanying et al. employed a bidirectional solid-state fermentation technique to ferment Tripterygium wilfordii, resulting in the production of Linglei mycelium [29]. Through the analysis of the main ingredient content before and after fermentation, it was observed that the content of triptolide, an active compound in Tripterygium wilfordii, decreased in Linglei mycelium after fermentation, which was directly associated with the detoxification effect of Tripterygium wilfordii.

4. Research Progress on Astragalus Membranaceus and its Medicinal Residues

Polysaccharides from Astragalus membranaceus are important herbal feed additives and have been widely used in animal husbandry production. They are considered as adjunct medications to chemical synthetic drugs in animal nutrition. Astragalus membranaceus polysaccharides effectively improve the utilization of nutrients in feed and promote animal growth. They accelerate the growth of livestock and poultry, enhance their resistance to diseases, and improve the quality and yield of animal products. It has been reported that piglets supplemented with herbal feed containing Astragalus membranaceus showed a significant increase in body weight, indicating its promotive effect on piglet growth. In summer, adding herbal preparations containing Astragalus membranaceus to the diet of laying hens improves egg production rate, egg quality, and feed efficiency, resulting in a notable increase in economic value. Huang Yifan et al. reported that adding a formulation containing Astragalus membranaceus polysaccharides to broiler feed at a specific ratio significantly increased body weight and feed conversion rate compared to the control group.

5. Conclusion

In conclusion, the development potential of traditional Chinese medicine can be effectively explored by making full use of the current development process of animal husbandry. However, to achieve this effect, it is necessary to solve the toxic and side effects of Chinese residue and the difficult to collect problems. Through solid fermentation or liquid fermentation, the toxic and side effects of Chinese residue should be minimized, and play a certain role in promoting the development of green and sustainable development.

References

[1] Feng, Y., Wang, E., Zhang, Z., et al. (2018). Nutritional value of Chinese herbal residues and their application in animal production progress. China Feed, 04: 19-22.

[2] Li, X., Wang, K., Su, Q. (2019). Application of Chinese herbal residues in major economic livestock and poultry production. Jiangxi Agriculture, 12: 132.

[3] Zhu, L., Jiao, Q., Yin, X., et al. (2015). Preparation of active substances from fermented Astragalus membranaceus residue as feed additive. Zhejiang Agricultural Sciences, 56(10): 1651-1653.

[4] Li, F., Wang, N., Zhang, S., et al. (2016) Comprehensive utilization and research progress of traditional Chinese medicine residues. Chinese Journal of Pharmaceutical Industry, 47(10):1322-1326.

[5] Yin, D., Shan, Y. (2018) Discussion on the resource utilization path and technological model of traditional Chinese medicine residues in the context of the big health industry. Science and Technology Innovation Herald, 15(13):96-100+102.

[6] Shao, S., He, J., Zhang, C., et al. (2021) Study on the reduction effect of traditional Chinese medicine residues on pig manure discharge in pig farming. Journal of Modern Livestock and Veterinary Medicine, (05):37-39.

[7] Li, Z., Lv, F., Yin, Y. (2021) Study on the effect of feeding fattening Hu sheep with traditional Chinese medicine residues. Journal of Animal Husbandry and Feed, 20(01):20-22.

[8] Li, Y., Zhang, J., Zhao, G., et al. (2020) Effects of traditional Chinese medicine residue and sediment on the growth performance and blood biochemical parameters of beef cattle in antiviral compound. Chinese Journal of Beef Science, 46(05):24-27.

[9] Qu, H., Liu, G., Ge, R., et al. (2018) Effects of compound donkey-hide gelatin decoction residue replacing coarse feed on blood parameters, organ index, and meat antioxidant capacity in donkeys. Feed Industry, 39(07):24-28.

[10] Li, Y., Su, S., Ni, J., et al. (2011) Effects of Leixiang Zhengqi medicine residue on the reproductive performance of lactating Rex rabbits. Chinese Feed, 11: 38-39+42.

[11] Li, H., Yang, G., Ren, M., et al. (2021) Research on the safety and application effect of fermented traditional Chinese medicine residue "Shiquan Dabu" for feed use" by in the Feed Research, 44(17):18-22.

[12] Xie, P., Zhu, Q., Kong, X., et al. (2018) Effects of fermented traditional Chinese medicine residue on fecal microbiota and metabolites in perinatal sows. Natural Product Research and Development, 30(04):686-691+646.

[13] Nie, M., Hu, L., Sun, Z., et al. (2018) Effects of fermented preparation of traditional Chinese medicine residue filtrate on growth performance and immune function of broilers. Southern Agriculture, 12(34):12-16.

[14] Sun, L. (2014) Physicochemical characteristics and greenhouse gas emissions from composting of traditional Chinese medicine residue. Thesis of Gansu University of Chinese Medicine.

[15] Yin, C., Liu, X., Yang, J., et al. (2020) Effects of different strains on the composting process and composition of traditional Chinese medicine residue. Journal of Gansu Agricultural University, 55(03): 97-104+112.

[16] Zhao, C., Wang, J. (2021) Feasibility study on the application of composting of two heat-clearing and detoxifying traditional Chinese medicine residues in sodic saline-alkali soil improvement. Journal of Jilin Agricultural University, 1-11.

[17] Chen, F., Yu, G., Zhang, H., et al. (2021) Effects of bio-organic fertilizer from traditional Chinese medicine residue on heavy metal content, microbial carbon and nitrogen content, and enzyme activity in Hg-Cd co-polluted soil. Henan Agricultural Sciences, 50(07): 66-75.

[18] Zhou, Z., Yu, G., Chen, F., et al. (2020) Effects of adding livestock and poultry manure on aerobic composting characteristics and degradation rates of cellulose and lignin in traditional Chinese medicine residues. Henan Agricultural Sciences, 49(10): 63-69.

[19] Jin, Q., Luo, J., Zhang, B., et al. (2019) Preparation of organic fertilizer from traditional Chinese medicine residue and its vermicomposting technology. Hubei Agricultural Sciences, 58(01): 35-38.

[20] Goldstein, E.J., Tyrrell, K.L., Citron, D.M. (2015) Lactobacillus species: taxonomic complexity and controversial susceptibilities. Clin Infect Dis., 60:98-107.

[21] Peng, K., Koubaa, M., Bals, O., et al. (2020) Recent insights in the impact of emerging technologies on lactic acid bacteria. Food Res Int., 137:109544.

[22] Valeriano, V.D., Balolong, M.P., Kang, D. (2017) Probiotic roles of Lactobacillus spin swine: insights from gut microbiota. J Appl Microbiol., 122:554-567.

[23] Zhang, L. (2021) Effects of Lactobacillus plantarum on growth performance, villi morphology, and fecal microbial content in weaned pigs infected with enterotoxigenic Escherichia coli. China Feed, 18: 45-48.

[24] Ren, L., Yang, L., He, F., et al. (2021) Research progress on the functionality of lactic acid bacteria and analysis of limiting factors for development. Food Safety Guide, 28: 135-136.

[25] Wang, Y., Wang, D., Zhang, S., et al. (2014) Research progress and prospects of traditional Chinese medicine microbial fermentation technology. Chinese Journal of Animal Health, 16(09): 22-26.

[26] Bao, F. (2020) Application research on feed fermentation process. Chinese Journal of Animal Health, 22(12): 51-52

[27] Tang, T., Wang, Q., Zhou, W., et al. (2020) Research, analysis, and application of solid-state fermentation technology. Industrial Microbiology, 50(05): 55-59.

[28] Li, G., Shen, Y., Wang, Q., et al. (2005) Study on saponin components in fermented Panax notoginseng. Chinese Traditional and Herbal Drugs, 04: 499-500.

[29] He, L., Lin, Z., Lu, J., et al. (2021) Research on detoxification and efficacy of thunder god vine based on bi-directional solid-state fermentation of Ganoderma lucidum. Journal of Beijing University of Chemical Technology (Natural Science Edition), 48(04): 48-56.