BIO Web of Conferences **60**, 01019 (2023) https://doi.org/10.1051/bioconf/20236001019
BFS 2022

Research Status of *Aurcularia Auricular* Polysaccharides Extraction and Functional Food: A Review

Xiaofeng Shi[1,2a*], Na Li[1b], Ying Cao[1c], Xuan Zhang[1d*]

[1]College of Public Health, Xi'an Medical University, Xi'an 710021, China
[2]Research Center for Medical Prevention and Control of Public Safety of Shaanxi Province, Xi'an 710021, China

Abstract: *Aurcularia auricular* polysaccharide (AAP) is a kind of acidic heteropoly sugar containing β-D-glucan, it has good biological activities. In this paper, the main components, extraction methods and development and application of AAP were systematically introduced, in order to provide new ideas and theoretical basis for promoting the creation of new products of AAP.

1 INTRODUCTION

The introduction as a kind of natural macromolecular compound, AAP is the main bioactive ingredients *Aurcularia auricular* accounted for over 65% of the dry weight. It has good biological activities such as anti-oxidation, anti-coagulation, anti-aging, anti-inflammation, anti-tumor, lowering blood sugar, lowering blood lipids, strengthening immunity and improving intestinal flora, thus attracting the focus of relevant research and development institutions and enterprises in the field of functional food at home and abroad. It mainly focused on the screening and cultivation of high-yielding strains of AAP, optimization of extraction and purification process, molecular modification of natural polysaccharides, biological activity mechanism and clinical application, research and development and production of functional food, etc.In this paper, the main components, extraction methods and development and application of AAP were systematically introduced, in order to provide new ideas and theoretical basis for promoting the creation of new products of AAP.

2 STRUCTURE AND COMPOSITION OF AAP

AAP is a kind of acidic heteropoly sugar containing β-D-glucan, wherein water-soluble β-d-glucan and water-insoluble β-d-glucan are connected by β-(1→3)-glycosidic bond (YIN, 2022). The monosaccharide composition of AAP mainly includes glucose, mannose, galactose, xylose, and a small amount of fucose and arabinose, with the relative molecular weight between 20 kDa~3000 kDa (YIN, 2022; XU, 2016). ZHANG Qian et al. found that AAP was mainly composed of fucose, arabinose, galactose, glucose and mannose with a molar ratio of 2.240:0.692:3.994:22.754:65.696, with a molecular weight of 410kDa (ZHANG, 2021). The AAP components extracted by KONG Peiyun included mannose, glucose, galactose, rhamnose, glucuronic acid, galacturonic acid, xylose and fucose. The average molecular weight was 665KDa, uronic acid was 0.23g/g, and sulfate was not detected (KONG, 2018). LIU Qian et al. found that the total sugar and uronic acid content of AAP in Qinba mountain area had no significant difference compared with that of AAP in Northeast China, which were mainly composed of mannose (60.87), glucuronic acid (20.83) and xyloss (9.86) (LIU, 2021). XU Siqi found that the extraction yield (53.02%) of AAP from Zhen'an of Shaanxi Province was much higher than that from Daxing'an Mountain range of Heilongjiang Province, Yichun of Heilongjiang Province, Anhui Province and Zhejiang Province. The antioxidant abilitycapacity and α-glucosidase inhibition ability of *Aurcularia auricular* varieties from Heilongjiang Province were the strongest.In vitro AAP from hydrolysate of monosaccharidewas mainly composed of mannose, glucosamine, glucose, galactose, xylose, arabinose with the molar ratio of 1.89:0.23:1.00:0.13:0.56:1.00 (XU, 2016). QIN Dandan used response surface method to optimize the degradation process of AAP, the results showed that contained α and β glycosides, it is mainly composed of mannose (57.1%), glucuronic acid (10.0%), rhamnose (0.4%), glucose (22.5%), galactose (2.9%), xylose (6.0%) and fucose (1.1%) (QIN, 2020). The monosaccharide composition, molecular weight, functional group and glycosidic bond connection mode of AAP were related to different varieties, origin and other sources as well as extraction, separation and purification methods, and had a significant effect on its biological activity.

* Corresponding author: a*sxfxy990307@xiyi.edu.cn
b13972236@qq.com, c172655263@qq.com, d*783519200@qq.com

3 EXTRACTION OF AURCULARIA AURICULAR POLYSACCHARIDE AND ITS INFLUENCING FACTORS

3.1.Extraction Technology of Aurcularia Auricular Polysaccharide

AAP are highly absorbable and colloidal, the extraction rate and biological activity of AAP from different varieties and different extraction processes are significantly different, and their active functions are closely related to related extraction processes (YIN, 2022), which mainly include hot water extraction, reflux, microwave assisted, ultrasonic assisted, ultrasonic enzyme assisted, etc. The extraction technology and its structure are shown in Table1. It was found that FU Lina et al. used ultrasonic assisted extraction of AAP to extract the optimal extraction conditions as solid-liquid ratio 1:40 (g/mL), ultrasonic time 20 min, ultrasonic temperature 50℃, ultrasonic power 100W, and the average extraction rate of 9.69% (FU, 2021). XU Siqi et al. found that the extraction rate of AAP by alkali extraction was up to 50.35%, that by enzyme extraction was 11.12%, and that by water extraction and alcohol precipitation was only 1.6%, Comprehensive consideration, the enzyme extraction is more suitable for the preparation of AAP (XU, 2016). KONG Peiyun optimized the high-temperature steam extraction process by response surface method, and the yield of AAP was increased by about 4 times compared with the traditional hot water extraction method (KONG, 2018). SUI Zhifang et al. extracted AAP by using complex enzymes in collaboration with ultra-high pressure method, and the extraction rate increased from 9.26% to 12.23% compared with using complex enzymes alone (SUI, 2021). The average extraction yield of AAP obtained by QIN Lingxiang et al. using dynamic ultra-high pressure microjet technology was 22.13%, higher than that obtained by hot water extraction (8.41%), microwave assisted extraction (14.08%) and ultrasonic assisted extraction (15.22%) (QIN, 2019). LIU Tong adopted ultrasonic microwave-assisted collaborative extraction of AAP with the highest yield (9.42%), which had significant differences compared with ultrasonic assisted extraction (7.61%), microwave-assisted extraction (6.27%) and hot water extraction alone (5.35%) (LIU, 2019). ZHAO Haibing et al. found that the yield of crude AAP by microwave assisted alkali method was 3.45 times of that by microwave method and 1.57 times of that by hydrothermal method, respectively with short time and low energy consumption (ZHAO, 2022).

LIU Qian et al. took *Aurcularia auricular* fruiting body from Qinba mountain area as raw material and *Aurcularia auricular* from Northeast China as the control, and extracted AAP by hot water extraction, compound enzyme and ultrasound. The results showed that there was no significant difference in sugar and uronic acid contents between AAP in Qinba mountain and northeast area determined, the content of AAP prepared by ultrasound and enzyme was significantly higher than that by hot water extraction. Compared with enzymatic and ultrasonic extraction, the contents of mannose and glucuronic acid in hot water extraction were the highest, and the contents of fucose and galactose were the lowest. Uronic acid content was in the order of hot water extraction>ultrasonic extraction>enzymatic extraction, and antioxidant capacity was in the order of ultrasonic extraction>enzymatic extraction>hot water extraction (LIU, 2021). SUN Yonggan et al. was compared the content and yield of crude AAP by 4 different extraction methods, including ultrasound, cellulase, ultrasound synergistic cellulase, ultrasound synergistic cellulase and trypsin. The results showed that the content of AAP extracted by ultrasound synergistic cellulase method was the highest (85.93%), and the yield was 1.55% (SUN, 2018). The antioxidant activity and α-glucosidase inhibitory activity of AAP obtained from enzyme extraction were the strongest in vitro, but there was no significant difference compared with that from alkali extraction. AAP obtained by alkali extraction has good antioxidant activity in nematodes (XU, 2016), and microwave-assisted AAP has the best anticoagulant activity, while ordinary alkali extraction polysaccharide has the lowest anticoagulant activity (LI, 2018).

Table1 Extraction technology and structure of AAP

Extraction method	raw material source	technological conditions	Extraction rate %	glycosidic bond configuration and molecular weight	main composition	Reference
Ultrasonic and microwave assisted collaboration	Engineering Research Center of Edible and Medicinal Fungi, Ministry of Education, Jilin Agricultural University	Material: liquid =1:80 (g/mL), ultrasonic 240 W, 85 ℃, 20 min	9.42	molecular weight =357.09KDa	Man:GlcA:Glc:Xyl =3.62:7.23:12.57:4.24	(LIU, 2019)

ultrasound synergistic cellulase	Jinggang mountains, Jiangxi province	Material: liquid =1:25 (g /m L), pH 4.5, 50 °C, 60 min, cellulase 0.6 g	1.55	β-pyran bond	Man:Glc:Gal:Xyl =16.98:48.43:2.44:12.90	(SUN, 2018)
Ultrasonic assisted by alkali-soluble alcohol precipitation	Wild *Aurcularia auricular* in Yichun, Heilongjiang Province	Material: liquid =1:100 (g/m), Ultrasonic 225 W, 70 °C, 25 min	14.07	α-D-Manp-(1→3)-α-D-Manp-(1→2,3)-α-D-Manp-(1→4)-β-D-GlcAp-(1→, molecular weight=9.772KDa	Man:GlcA:Glc:Xyl =89:25:30.5:4.25:1	(BIAN, 2020)
hydroextraction and alcoholic precipitation	Xizang Milin Bang zhong Fungi Co.LTD	90 °C、240 min	63.77	-	GlcA:Man:Glc:Gal: GlcN:Fuc:Xyl:Ara =14.69:73.89:258.35:53.88: 1.86:11.54:11.91:1.32	(HUANG, 2021)
Ultrasound-assisted hot water extraction	Zhongkang Vegetable Planting Co., LTD	Material: liquid =1:60(g/mL), ultrasonic 180 W, 60 °C, 20 min	10.2	-	Principal Glc and Man, Glc:Man:Xyl:Fuc:Gal: GlcA= 13.47:8.64:2.13:1.95:1.69:1.00	(BAI, 2021)
Alkali extraction	For sale (place of origin unknown)	Material: liquid =1:160 (m/V), 80 °C Heat and stir with the water bath 180min	52.08	-	Principal Man, Man:GlcN:Glc:Gal:Xyl :Ara= 1.00:0.12:0.53:0.07:0.29:0.53	(RUAN, 20220
Alkali extraction and alcoholic precipitation	*Aurcularia auricular* from Greater Khingan Mountains, Heilongjiang (purchased from farmers' market)	Material: liquid =1:160 (m/V), 80 °C, 1% NaOH extraction 180 min,76% Ethyl alcoholic precipitation	-	Principal β configuration, β-Glc(1→3)-glycosidic bond, β-Glc(1→4)-, β-Gal(1→4)-glycosidic bond And α-Glc-glycosidic bond, molecular weight=93.62kDa	Glc:Gal: Fuc =50:1:2	(XU, 2018)
High temperature steam extraction	Yanbian, Jilin Province	Material: liquid =1:50 (g /mL), 120 °C, 85 min	37.49	β-(1,3-)glycosidic bond	Man:Rha:Glc:Fuc:Xyl: Gal =1:0.62:0.27:0.05:0.04: 0.02	(ZHUANG, 2020)
hot water extraction	For sale (place of origin unknown)	Material: liquid =1:60(g /m L), 100 °C, 210 min	8.03	α-glycosidic and β-glycosidic bond, Molecular weight =148.2KDa	Man:Glc:GlcA:Xyl:Gal =38.03:42.66:7.50:7.44 :2.93	(CAO, 2021)

Note: Man-Mannose, Xyl-Xylose, Rha-Rhamnose, Glc-Glucose, Gal-Galactose,GlcA-Glucuronic acid, Ara-Arabinose, GalA-Galacturonic acid, Fuc-Fucose, Fru-Fructose, GalN-galactosamine, GlcN-Glucosamine

3.2.Influencing Factors of Aurcularia Auricular Polysaccharide

In the extraction process, temperature and time are the key factors affecting the extraction yield, structural stability and biological activity of AAP (YIN, 2022). The optimal extraction process of AAP by hot water extraction was explored through single factor and response surface analysis. CAO Huixin found that the main factors affecting the yield of AAP were extraction time,followed by extraction temperature and liquid-solid ratio (CAO, 2021). ZHANG Haiyan took AAP yield as the evaluation index, and found that temperature was the biggest factor affecting the optimal extraction rate of AAP, followed by extraction time and liquid-solid ratio (ZHANG, 2019). Compared with the traditional hot water extraction method, the optimized ultrasonic extraction method by response surface analysis can effectively reduce the water bath temperature, shorten the extraction time and improve the extraction rate of AAP. The influencing factors are ultrasonic frequency, ultrasonic water bath temperature, ultrasonic time and solid-liquid ratio in order (ZONG, 20200. Among the influential factors for the extraction of AAP (extraction rate 22.52%) by ultrasonic-coordinated semi-bionic method, solid-liquid ratio>ultrasonic temperature>ultrasonic power>ultrasonic time, and the effects of solid-liquid ratio and ultrasonic temperature were significant, while others were not (HAO, 2021). Ultrasonic power had the greatest influence on extraction of AAP, followed by ultrasonic temperature, and the influence of ultrasonic time is small (FU, 2021). The influencing factors of extraction of AAP by complex enzyme combined with ultra-high pressure method are as follows: holding time>extraction temperature>pressure>solid-liquid ratio, among which holding time has a significant effect on the yield of AAP, while other factors are not significant (SUI, 2021). QIN Lingxiang et al. found that extraction time and solid-liquid ratio had significant effects on the yield of AAP (P=0.05), while other factors had no significant effects (QIN, 2019). XU Hailin et al. believed that the order of factors affecting the extraction rate of AAP in water extraction was the particle size of the dried material>extraction time>stirring speed>liquid-to-solid ratio (XU, WU, 2016). LIU Tong's investigation results showed that: The influence degree of ultrasonic microwave-assisted collaborative extraction of AAP on the yield was in the order of ultrasonic power>solid-liquid ratio>microwave temperature>synergistic time (LIU, 2019). ZHAO Haibing et al. believed that the factors affecting the extraction yield of AAP were alkali concentration>liquid-solid ratio>microwave power (ZHAO, 2022).

The comprehensive analysis showed that the single extraction method had different degrees of defects, and different auxiliary extraction techniques had different effects on the structure or functional group content of AAP. The optimization of the extraction process of AAP could shorten the extraction cycle, reduce energy consumption, and effectively improve the yield of AAP,with its large molecular weight and high uronic acid content, stable chemical structure and good biological activity.

4 DEVELOPMENT OF FUNCTIONAL FOOD WITH APP

The processing of *Aurcularia auricular* is divided into primary processing and deep processing. The primary processing is to make dry products after drying fresh *Aurcularia auricular*.The development of deep processing products with *Aurcularia auricular* as raw materials is still in the initial stage, mainly including *Aurcularia auricular* beverage, *Aurcularia auricular* nutritional powder, *Aurcularia auricular* conporridge and ready-to-eat *Aurcularia auricular*, etc., among which the functions of functional food are mainly to help reduce blood lipid and enhance immunity, as shown in Figure 1 and Figure 2.In order to effectively utilize the good biological activity of AAP, XUE Yiting and ZHAI Lili et al used AAP and pure milk as raw materials, and selected a mixture of *Streptococcus thermophilus*,*Lactobacillus bulgaricus* and *Lactobacillus casei* as starter culture. The sensory score (9.30 points) and water retention (72.14%) of AAP solidified yoghurt were better than those of ordinary yoghurt (8.83 points, 63.83%), and the texture properties, free amino acids and extracellular crude AAP were significantly increased ($P<0.05$). The fat content (2.35%) was significantly ($P<0.05$) lower than that of ordinary yogurt (4.16%), and the nutritional value and health care effect were higher (XUE, 2020; ZHAI, 2022). In order to reduce the molecular weight of AAP and improve its utilization value, QIN Dantan adopted response surface method to optimize the enzymatic degradation process,and developed black fungus wolfberry compound beverage with AAP and black wolfberry as raw materials. The scavenging rates of DPPH free radical, ·OH and $\cdot O2^-$ were 59.20%,43.60% and 67.45%, respectively (QIN, 2020). Using AAP and red bean as raw materials and AGAR as gel agent, SHEN Shibin et al. developed AAP instant food soup with beautiful appearance and fresh taste without adding any artificial pigment. The best formula was as follows:AAP 2.0%, red bean paste 30%, AGAR 1.0%, white granulein sugar 2.0% (SHEN, 2017). SHAO Xinru et al. used AAP to replace the thickening agent food glue to prepare a new type of AAP icecream product, which has a unique flavor and good edible quality, and maximally improves the nutritional value and edible safety of the icecream product (SHAO, 2020). ZHANG Hua et al. invented a kind of soft QQ sugar which can enhance immunity, resist fatigue, protect eyesight and not cause caries easily. It is composed of AAP, blueberry and raspberry fresh fruit concentrate juice, hawthorn extract and jujube extract, edible gelatin, pectin, AGAR, xylitol, maltitol and sodium citrate, which can effectively meet children's health needs (ZHANG, 2021). WANG Jun made health care chewable tablets with superfine powder and AAP as raw materials, fillers, flavor correction agents, adhesives and other auxiliary materials by wet grain pressing method. The tablets are sweet and sour, with unique flavor, and have the effects of lowering blood lipid, lowering blood sugar, anti-oxidation and improving stomach and intestines (WANG, 2019). The AAP energy glue invented by ZHAO Yuhong et al can significantly prolong the weight-bearing swimming time of mice, reduce the content of blood lactic acid and blood urea nitrogen, increase the glycogen reserve of the body and significantly resist fatigue and eliminate fatigue (ZHAO, 2018). By pretreating dried *Aurcularia auricular*, pulverizing, sieving, extraction at low temperature, filtering and other processes, ZENG Lijian et al. prepared AAP sports drinks, which are rich in nutrition, transparent in color, fresh in taste, stable, not easy to rot and can be preserved for a long time (ZENG, 2017).

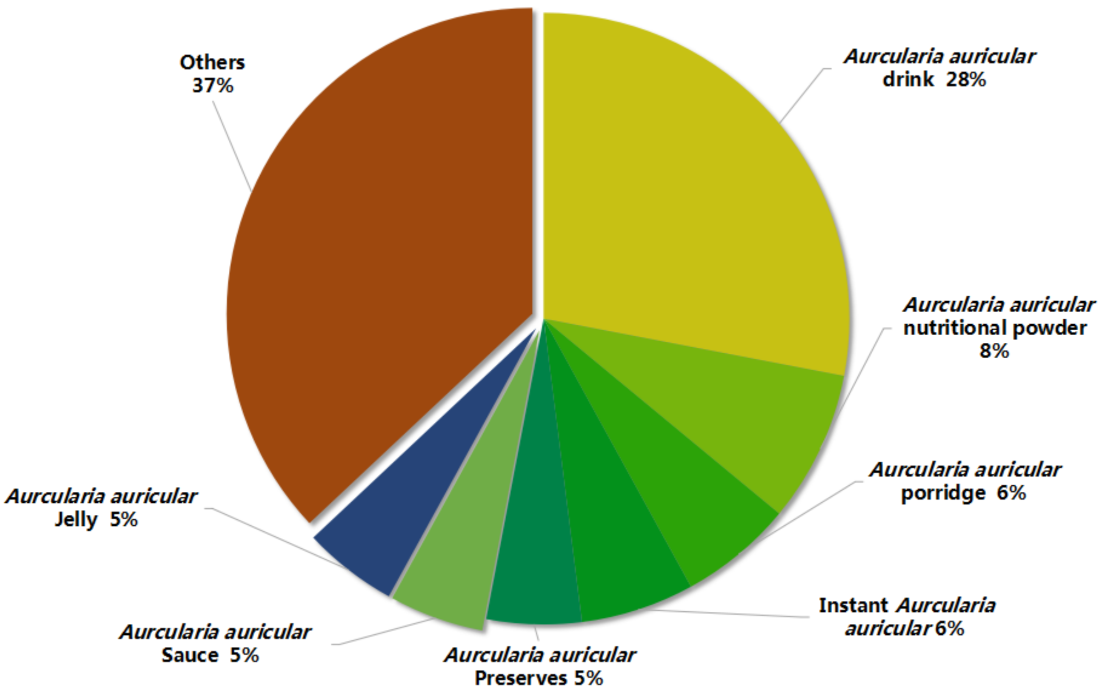

Fig.1 Market share of Chinese *Aurcularia auricular* product

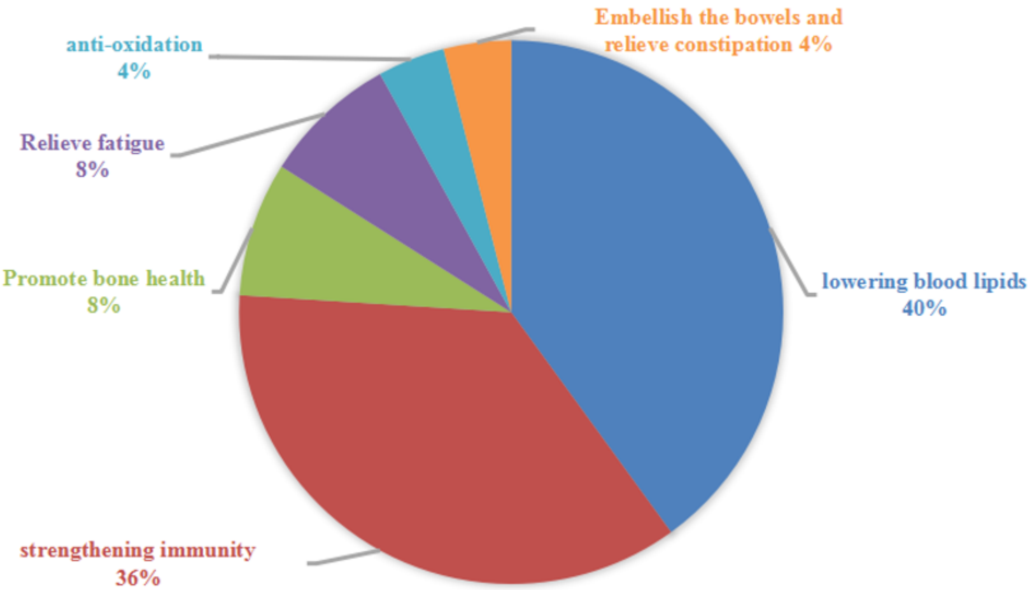

Fig.2 Market share of *Aurcularia auricular* related functional food

5 CONCLUSION

The monosaccharide composition, molecular weight, functional group and glucosidic bond connection of AAP are related to the varieties, origin and other sources and extraction technology of AAP, and it has high water absorption and colloidal properties. The extraction yield and biological activity of AAP obtained by different varieties and different extraction processes were significantly different, and its activity function was closely related to related extraction processes. Therefore, the extraction of AAP should be comprehensively considered. Therefore, it is very important to seek and optimize the suitable extraction technology which can improve the yield of AAP without damaging its structure and biological activity, and has strong operability and economic feasibility. It is of great significance to further study the biological activity of AAP, develop functional food with AAP, extend the industrial chain of *Aurcularia auricular* to improve the added value of products, and promote the healthy development of AAP industry.

REFERENCES

1. BAI Yunfei, WANG Yanan, LIU Xintong, et al. Effects of *Aurcularia auricular* Polysaccharides on

Intestinal Microflora in Rats Fed High-fat Diet[J]. Food Research and Development, 2021, 42(19):44-52.

2. BIAN Chun. Isolation and Structural characterization of anticoagulant polysaccharide from *Aurcularia auricular* and its inhibitory mechanism on thrombosis [D]. Harbin Institute of Technology, 2020.
3. CAO Huixin. Study on Preparation and antioxidant activity of *Aurcularia auricular* polysaccharide[D]. Changchun University, 2021.
4. FU Lina, ZHENG Jiadong, MENG Huirong, et al. Optimization of extraction process and antioxidant activity of *Aurcularia auricular* polysaccharide[J]. Cereals & Oils, 2021, 34(08):93-96.
5. HAO Huimin, ZONG Wei. Optimization of Ultrasonic Assisted Semibionic Extraction of *Aurcularia auricular* polysaccharide [J]. Food Research and Development, 2021, 42(8):109-112.
6. HUANG S L. Study on Hypolipidemic Activity of Crude Polysaccharide from Xizang *Aurcularia auricular*[D]. Xizang Agriculture and Animal Husbandry College, 2021.
7. KONG Peiyun. Study on extraction and function of active *auricularia* polysaccharides[D]. East China University of Science and Technology, 2018.
8. LI Dehai, GU Jialin, SUN Changyan, et al. Effects of Extraction Techniques on Anticoagulant Activity of Acid-*Aurcularia auricular* Polysaccharides[J]. Journal of South China University of Technology(Natural Science Edition), 2018, 46(06):93-102.
9. LIU Qian, ZHANG Xinyu, WANG Yan, et al. Physicochemical properties and antioxidant activities in vitro of *Aurcularia auricular* polysaccharide in Qinba mountain area[J]. Food and Fermentation Industries, 2021, 47(23):91-97.
10. LIU Tong. Studies on the Preparation and Characterization of *Aurcularia auricular* polysaccharide-iron complex and its Anti-iron deficiency Anemia Activity[D]. Jilin Agricultural University, 2019.
11. QIN Dandan. Enzymatic hydrolysis, antioxidant activity and application of polysaccharide from *Aurcularia auricular*[D]. Changchun University, 2020.
12. QIN Lingxiang, ZHOU Jingqi, CUI Shengwen, et al. Study on Extraction of Polysauharides from *Aurcularia auricular* by Dynamic High Pressure Micro-fluidization Technology[J]. Food Research and Development, 2019, 40(19):155-159.
13. RUAN M Q. Separation, preparation and Monosaccharide composition of *Aurcularia auricular* polysaccharide [J]. Modern Food, 2022, 28(11):146-148.
14. SHAO Xinru,SUN Haitao,XU Jing,et al.A kind of *Aurcularia auricular* icecream and its preparation method [P].JiLin:CN111493201A,2020-08-07.
15. SHEN Shibin,TONG Lijun,YAO Hongwei,et al.Research on the Processing Technology of *Aurcularia auricular* polysaccharideFast-food Soup [J].Forest By Product and Speciality in China,2017(04):1-4.
16. SUI Zhifang, LIU Yanqi, QIN Lingxiang. Extraction Optimization of *Aurcularia auricular* Polysaccharides by A Compound Enzyme-Assisted Ultra-High Pressure Method[J]. Food Research and Development, 2021, 42(24):107-113.
17. SUN Yonggan, YAN Weiwei, NIE Shaoping, et al. Preparation and Structure Analysis of *Aurcularia auricular* Polysaccharide from Jinggang Mountains[J]. Modern Food Science and Technology, 2018, 34(03):39-45+67.
18. WANG Jun.Preparation method of freeze-dried edible fungus whole powder health chewable tablets rich in *auricularia* polysaccharide[P].AnHui:CN109315759A,2019-02-12.
19. XU Siqi. Study on the screening and preparation of *Aurcularia auricular* polysaccharide simulated hydrolysate and its hypoglycaemic effect[D]. ZHeJiang: China Jiliang University, 2016.
20. XU Yaoyao. The study on antioxidant activity and antidiabet acctivity of polysaccharide hydrolysate from *Aurcularia auricular*[D]. ZHeJiang:China Jiliang University, 2018.
21. XU Hailin, WU Xiaoyong, NIE Shaoping, et al. Optimization of extraction conditions of crude polysaccharide from *Aurcularia auricular* and its effects on the functions of mouse peritoneal macrophages [J]. Food Science, 2016, 37(10):100-104.
22. XUE Yiting, BAI Hongxia,LI Mingjie,et al.Optimization of Fermentation Process of Set Yoghurt witll *Aurcularia auricular* Polysaccharides[J].Science and Technology of Food Industry,2020,41(16):156-162.
23. YIN Hong, ZHAO Shijing, HAN Shanshan, et al. Research Progress on Extraction,Purification,Structure Characterization and Biological Activity of *Aurcularia auricular* Polysaccharide [J]. Food Industry, 2022, 43(08): 269-273.
24. ZENG Lijian, LIZaigui,WANG Lijuan,et al.A kind of *auricularia* polysaccharide sports drink and its preparation method[P].JiangXi:CN106578792A,2017-04-26.
25. ZHANG Haiyan, CHEN Shaohui, YANG Weiping. Optimization of Extraction Technology of *Aurcularia auricular* Polysaccharide [J]. Nongyekejiyuxinxi, 2019(13):40-43.
26. ZHANG Qian, LIU Yu, DAI Xiaojing, et al. Structure analysis of *Aurcularia auricular* polysaccharide and its protective activity against oxidative damage of hepatocytes [J]. Fungal Research, 2021, 19(3):170-176.

27. ZHAO Haibin, ZHANG Jian, HAO Yilin, et al. Optimization of microwave-assisted alkaline extraction of crude polysaccharide from *Aurcularia auricular* by response surface methodology[J]. Journal of Wuhan Polytechnic University, 2022, 41(05):26-33.
28. ZHUANG W. Study on extraction, Structural analysis and activity function of *Aurcularia auricular* polysaccharide[D]. East China University of Science and Technology,2020.
29. ZHAI Li-Li, YOU Da-Peng.Optimization process of *Aurcularia auricular* polysaccharide yoghurt by response surface method[J].Journal of Food Safety and Quality, 2022,13(21):7111-7117.
30. ZHANG Hua, ZHOU Xintao,WANG ZHengyu,et al.A multifunctional QQ sugar for children and its preparation method [P]. Heilongkiang: CN108041239B ,2021-07-20.
31. ZHAO Yuhong,WANG Zhenyu,DANG Yuan,et al.A kind of *Aurcularia auricular* polysaccharide energy glue with anti fatigue function [P]. Heilongjiang: CN105192514B,2018-11-30.
32. ZONG Li-na, LI Cheng-shuai. Optimization of Ultrasonic Extraction of Crude Polysaccharide From *Aurcularia auricular* [J]. Contemporary Chemical Industry, 2020, 49(6):1118-1122.