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Research Progress of Coffee Grounds and Its Prospect in Food Field

Li Yang, Xueling Li, Xi Li, Qingqing Hong, XuRundong Kan*

School of Biology and chemistry, Pu`er University, Pu`er, 665000, China

*Corresponding author: kanxurundong@163.com

Abstract

Coffee grounds are by-products of coffee production, and their resource utilization has attracted much attention. It is rich in carbohydrates, proteins, lipids and various mineral elements, as well as polyphenolic compounds such as caffeic acid, chlorogenic acid, etc. These ingredients show antioxidant, anti-inflammatory, anti-cancer, blood sugar regulation and other biological activities. The study found that coffee grounds can be used as a source of high-quality dietary fiber, which contains rich mannan, and can be used to prepare manno oligosaccharides as functional food additives. Coffee oil is a valuable natural flavor oil, which can be used for food flavoring or making essence. In addition, coffee grounds can be used as microbial culture media to cultivate a variety of edible fungi. With the increasing demand for coffee, the comprehensive utilization of coffee grounds has broad prospects, can give full play to the value of resources, and is of great significance for promoting green ecological civilization.

Keywords

Coffee grounds; Active ingredients; Applied research.

1. INTRODUCTION

Coffee belongs to Rubiaceae, and its origin is Ethiopia. It grows in the tropics or subtropics. Yunnan and Hainan in China are the main cultivation areas. At present, the production and consumption of coffee rank first among the three major beverage crops in the world, becoming the second raw material productafter oil. According to the market survey of the International Coffee Organization, the global coffee consumption in 2020 will be 9997700 tons, and the annual production of coffee grounds will exceed 9.6 million tons. As the residue of instant coffee production, coffee grounds account for about 2/3 of the dry weight of coffee beans . However, at present, the main treatment methods of coffee grounds waste are incineration and sanitary landfill, which not only fail to realize the resource utilization of coffee grounds, but also may cause environmental pollution, which is obviously against the current concept of green ecological civilization.

Research shows that the main components of coffee grounds include carbohydrates, proteins, lipid compounds and mineral elements . Yang Yang and others found that coffee grounds after detection contained 8.74% crude protein, 5.81% fat, 17.2% crude fiber, phosphorus, zinc, iron, manganese, magnesium and other mineral elements. It is reported that coffee grounds contain rich caffeic acid, chlorogenic acid, polyphenols, tannins and other bioactive substances. In recent years, a lot of research has been carried out on coffee grounds as fertilizer, feed and fuel at home and abroad, but the application of coffee grounds in the food field has rarely been reported. Due to the huge market potential and the sharp increase in output, the number of coffee grounds remaining after processing has increased, and the comprehensive utilization of

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coffee grounds has received more and more attention. Therefore, scientific evaluation of the value of coffee by-products is of great significance for the full use of agricultural by-products and development and utilization.

2. BIOACTIVE INGREDIENTS IN COFFEE GROUNDS

2.1. Dietary fiber

Coffee grounds are rich in wood fiber, various functional ingredients, oil and other substances, and have better physiological activity than ordinary vegetable and fruit dietary fiber. Kaixing found that the contents of crude fiber, neutral detergent fiber, acid detergent fiber and lignin in coffee grounds were significantly higher than those in coffee shells, coffee fruits and coffee beans ($P<0.01$), while the corresponding value of coffee shells was the lowest, reflecting its highest feeding value. Zhang Xinyue and others used coffee grounds as raw materials, extracted dietary fiber by double enzyme method in alkaline environment, and studied its performance. They found that its ultra-high pressure modified dietary fiber from coffee grounds had better water absorption and swelling effect. Vzquez - Snchez and others evaluated the antioxidant dietary fiber extracted from coffee grounds and found that antioxidant dietary fiber is a potential functional food component, which plays an active role in controlling sugar metabolism and is friendly to diabetic patients. Dunia Maria and others found that the total fiber content in coffee grounds was higher than that in coffee beans, which could be fermented by colonic microbiota to produce short chain fatty acids β And IL-5 cytokines inhibit the production of NO in macrophages to play an anti-inflammatory role.

2.2. Mannan

The hemicellulose part of coffee grounds usually contains a large amount of mannan, which can be hydrolyzed by acid, alkali or enzyme to prepare manno oligosaccharides. As a unique functional food additive, manno oligosaccharides have a very broad development prospect. Huang Guangmin et al. extracted D-mannose from coffee grounds by sulfuric acid hydrolysis, with a yield of 28%~30%. Guo Yueping made use of the coffee bean dregs left by the water extraction of chlorogenic acid to prepare manno oligosaccharides with high added value by enzymatic method. He found that the content of mannose in the oligosaccharide component was high, which met the requirement that functional oligosaccharides should be manno oligosaccharides. Coffee grounds are used to produce valuable biological products, including oligosaccharides, manno oligosaccharides, mannose and bioethanol [18] . Jie Gu et al. extracted galactomannan from coffee grounds by self hydrolysis and enzymatic hydrolysis, with the purity of 81.7% and 76.4% respectively. The extracted galactomannan showed better free radical scavenging ability and biological activity; It is beneficial to the proliferation of intestinal probiotics, promotes the proliferation of macrophages and their production of NO, and can also be used as a potential immune agent. Eilhann et al.

2.3. Coffee oil

Coffee oil is a valuable natural aromatic oil extracted from coffee grounds. It can be used as a flavoring agent or flavor enhancer of food, and also can be used to make coffee essence. In 1998, Silval and others used ether to extract oil from coffee grounds for the first time. Ricardo and others use supercritical carbon dioxide to extract coffee grounds, and the total amount of oil can reach 85%. Chen Yipingextracted coffee oil from coffee grounds with organic solvent, and the obtained coffee oil has good antioxidant property and thermal stability. Li Xiaojiaoet al. extracted coffee oil with ethanol for 8 h at a material to liquid ratio of 5 ： 28g/mL, degummed, deacidified and decolorized, and obtained a final purification rate of 29.8%. It is reported that coffee oil contains 11 kinds of fatty acids, including 34.79% linoleic acid and 42.12% palmitic acid. Deotale S M et al. further extracted caffeinol, caffeinol and dibei substances with

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physiological regulation function from coffee oil. The coffee residue oil contains 343.4~1146.3 mg/kg phytosterol, which has the ability of anti-cancer, anti-inflammatory and liver protection.

2.4. Phenols

Plant polyphenols can not only be directly taken in through diet, but also can be added to nutritional health products as functional ingredients. They can also be used as antiseptic and fresh-keeping agents because they can effectively inhibit the growth of microorganisms. It is reported that coffee grounds contain a variety of polyphenols closely related to human health, mainly including chlorogenic acid, caffeic acid, ferulic acid, gallic acid, protocatechuic acid, rutin, etc. [28] , of which chlorogenic acid is the main dietary polyphenol in coffee grounds, and its concentration level is similar to that in coffee drinks. These secondary metabolites have a variety of biological activities, such as anti-oxidation, anti-virus, anti-bacterial, anti-cancer, anti-inflammatory, hypoglycemic. The antioxidant effect of chlorogenic acid can be used to prevent colon cancer and regulate intestinal flora. Chlorogenic acid residues exist during coffee roasting, which can release high antioxidant activity through colon fermentation. Pharmacokinetic study shows that about one-third of the chlorogenic acid ingested in the body is absorbed in the stomach and proximal duodenum, and can also be split into caffeic acid and quinic acid by intestinal flora. Quinic acid has neurotrophic and protective properties. The study found that the antioxidant activity of total phenolic compounds in coffee grounds containing samples was significantly higher than that of control samples. During the simulated digestion period, the highest bioavailability of polyphenols in coffee grounds was observed after the colon phase, indicating their potential advantages for human health [33] . Therefore, chlorogenic acid can be used as functional food or dietary supplement and drug additive. Phenolic compounds in coffee grounds can protect cells from oxidative damage, and have certain anti-inflammatory and anti allergic activities. Compared with relatively low-grade coffee green bean phenols, they show more significant anti-tumor activities, which may be due to the role of brown pigments (melanoids and phenolic polymers) formed during baking.

Emanuel Vamanu et al. investigated the biological activities and bioavailability of three coffee grounds polyphenols with different roasting degrees in vivo and in vitro. The results showed that these three coffee grounds polyphenols all showed good anti-inflammatory and antioxidant activities, which could inhibit the proliferation of tumor cells and regulate the colonic microbiota . Alvarez S and other researchers found that the oil content of coffee grounds samples was 6.3~10.5%, of which linoleic acid (43%), palmitic acid (33.4%) and oleic acid (11%) were the main components. Through anti collagenase and anti elastase experiments, coffee grounds showed good anti-aging activity, and IC50 value was equivalent to epigallocatechin gallate; Gallic acid was positively correlated with the free radical scavenging capacity and the inhibition of elastase measured by DPPH. Margherita Pettinato et al. [37] used human keratinocytes NCTC 2544 to test the coffee residue extract rich in caffeine and polyphenols to evaluate its biocompatibility. BalzanoA et al. found that microwave assisted extraction can achieve a polyphenol extract with high antioxidant activity. The antioxidant activity of FRAP and DPPH showed a good correlation with the total polyphenol content (TPC), and the related factors were high. Wu Kejiang used ultrasonic assisted extraction technology, the maximum yield of polyphenols was 53.37mg/g, 11.56% higher than that of traditional solvent extraction, the DPPH clearance rate of the product was 90%, and the product had strong antioxidant activity .

3. AS MICROBIAL CULTURE MEDIUM

Coffee grounds are rich in oil, sugar, protein and other nutrients and trace elements, which are easier to be decomposed and utilized by microorganisms. It is faster and more effective to use coffee grounds as a substrate to cultivate microorganisms. It was the first report on the

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successful cultivation of Pleurotus ostreatus, Pleurotus edodes, Flammulina velutipes and Lentinula edodes using coffee grounds. Xiao Zitian [41] and others cultivated Ganoderma lucidum using coffee grounds and improved the formula. By optimizing the formula of coffee grounds, the biological efficiency of pleurotus ostreatus was increased by 12.8%. Dong Lei et al. used coffee grounds to replace 6% of the rice in the conventional cultivation formula of Cordyceps militaris, and the harvested fruiting bodies performed well or even significantly better than the control. When the coffee grounds were added at 20%, the growth indicators, nutritional components and volatile flavor components of Pleurotus eryngii were the best. Tao Yuou and others used coffee grounds instead of cottonseed hulls to cultivate Pleurotus ostreatus. They found that adding 10% coffee grounds could increase the yield of Pleurotus ostreatus, while adding 30% or more would reduce the yield of Pleurotus ostreatus.

Li Zhuoting and others tried to ferment coffee grounds with yeast, and successfully produced coffee grounds wine with unique fragrance and soft and harmonious wine body by screening appropriate strains and additives. Sampaio et al. Wei Min et al. found that the aroma components of coffee extract changed after microbial fermentation, and the aroma quality was improved. Xu Qianqian et al., Lactobacillus plantarum fermentation can promote the release of activity and flavor substances in coffee grounds. The content of total phenols and proteins in coffee grounds fermentation products increased significantly, and the content of pyrazine, furfuryl acetate and other flavor substances increased significantly. Murthy et al. fermented different substrates by Neurospora crassa and found that coffee pulp, peel, silver peel and coffee grounds were induced by a mixture of equal proportions α- The effect of amylase was the best .

4. CONCLUSION AND PROSPECT

With the growing demand for coffee, the output of by-product coffee grounds is also growing rapidly, so the resource utilization of coffee grounds is more and more concerned by researchers. Coffee grounds contain carbohydrates, proteins, lipid compounds and mineral elements. They are rich in caffeic acid, chlorogenic acid, polyphenols, tannins and other bioactive substances. They have antioxidant and lipid regulating functions. Their development prospects and application research are of great value.

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