油脂化学

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核桃多酚类物质生物活性研究进展

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摘要:核桃富含多酚类物质,尤其是在核桃加工副产物中,如青皮、壳、内种皮、分心木等,然而这些副产物常被当作废弃物来处理,附加值低。综述了核桃多酚类物质的抗氧化、抗炎、抗肿瘤、预防心血管疾病、健脑、预防或治疗糖尿病等生物活性,以期为核桃副产物的综合开发利用提供科学依据。

关键词:核桃;多酚;生物活性;抗氧化;抗肿瘤;预防心血管疾病

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Progress on bioactivity of walnut polyphenols

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Abstract: Walnuts are rich in polyphenols, especially in the by-products of walnut processing, such as green husk, shell, pellicle, diaphragm, etc. However, these by-products are often treated as waste and have very low value. The bioactivities of walnut polyphenols, such as antioxidant, anti-inflammation anti-tumor, prevention of cardiovascular disease, nutritional value on the human brain, prevention or treatment of diabetes and other bioactivities were reviewed so as to provide a scientific basis for the comprehensive development and utilization of walnut by-products.

Key words: walnut; polyphenols; bioactivity; antioxidant; anti-tumor; prevention of cardiovascular disease

核桃(*Juglans regia*)属胡桃科胡桃属植物,具有较高的营养价值和商业价值。我国已成为世界上最大的核桃种植国,主要分布在云南、新疆、河北、陕西等省[1-2]。近年来,随着我国核桃种植面积与产量越来越大,核桃加工过程中产生了大量的副产物,如核桃青皮、壳、内种皮、分心木、饼粕等,目前我国对这些副产物的利用率不高,其附加值低[3-4]。研究表明,这些副产物富含多酚类物质。核桃以其脂质特征而闻名,然而在核桃对机体营养与功效方面,核桃多酚的生物活性甚至超过了脂质[5]。植物多酚具有抗氧化、抗肿瘤、预防心血管疾病(CVD)等多种活性,其中核桃多酚已成为目前的研究热点[6]。本文对近年来核桃多酚的生物活性进行综述,旨在为核桃副产物的综合开发利用提供科学依据。

1 核桃多酚的组成

核桃多酚类化合物主要为鞣质、黄酮类和酚酸。万政敏等[7]从核桃内种皮中共检测到17种酚类物质,其中没食子酸含量(146.2 mg/100 g,干基)最高。魏欢等[8]从核桃青皮中分离获得10个单体化合物,并对其结构进行了鉴定。Regueiro等[9]从核桃中共分离鉴定出120种酚类化合物,其中鞣花单宁(Ellatitannins)、鞣花酸(Ellagic acid)及其衍生物为核桃多酚的主要成分。

2 核桃多酚的生物活性

2.1 抗氧化与抗炎活性

植物多酚可以有效清除自由基,具有抗氧化和抗炎活性[10]。大量研究证实核桃多酚在体内外均具有较强的抗氧化活性,其抗氧化活性与芳香环中羟基数量有关[11-12]。核桃多酚在体外可以清除羟自由基、超氧阴离子自由基、过氧化氢自由基、DPPH自由基、ABTS自由基等[13]。体内实验表明,核桃多

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酚通过提高机体抗氧化酶活性,减轻氧化应激从而降低多种疾病的发病率[14]。核桃多酚中,研究较深入的成分为鞣花酸及其代谢产物尿石素,它们在机体内可抑制相关炎性因子的表达从而减轻炎症反应,如核转录因子 - kappa B(Nuclear factor - kappa B,NF - κB)、诱导型一氧化氮合酶(Inducible nitric oxide,iNOS)、肿瘤坏死因子 α(Tumor necrosis factor - alpha,TNF - α)、白细胞介素 - 1β(Interleukin - 1β,IL - 1β)等[15]。目前,植物多酚在机体肠道中的代谢产物尿石素的多种生物活性不断被发现,其显著的抗氧化和抗炎功能已成为研究热点[16]。

2.2　抗肿瘤活性

恶性肿瘤是全世界主要的慢性退行性疾病之一,相对于传统治疗药物,植物多酚通过多种机制发挥其抗肿瘤作用[17]。近年来,诸多研究表明核桃多酚具有显著的抗肿瘤活性。如:核桃多酚可以抑制结肠癌细胞的增殖和分化,其机理可能是通过调控线粒体途径或 Wnt/β 连环蛋白信号通路相关基因或蛋白的表达实现[18-19];核桃多酚通过抑制机体雄激素受体和前列腺特异性抗原蛋白的表达从而诱导前列腺癌细胞的凋亡[20]。Anderson 等[21]从核桃多酚中分离纯化获得的鞣花酸,能抑制人类外周血单核细胞的增殖。

2.3　降血压及保护心血管活性

核桃多酚通过降低血脂、胆固醇和低密度脂蛋白(LDL),增加高密度脂蛋白和抗氧化防御系统来预防或治疗 CVD[22-23]。核桃多酚能抑制 LDL 被氧化生成氧化修饰型 LDL,从而防止胆固醇堆积在动脉壁上诱发动脉粥样硬化[24]。在机体 CVD 发生过程中,炎症细胞因子诱导的内皮细胞黏附分子的过量表达被认为是动脉粥样硬化形成的主要原因,而核桃多酚能通过降低 TNF - α 诱导的血管内皮细胞黏附分子 - 1(VCAM - 1)和动脉内皮细胞间黏附分子 - 1(ICAM - 1)蛋白的过量表达来减轻动脉粥样硬化[25-26]。

2.4　健脑活性

核桃多酚的健脑活性主要是基于其强大的抗氧化、抗神经炎症、改善脑血流等活性[27]。Shi 等[28]研究表明核桃多酚能够改善高胆固醇血症小鼠的学习和记忆功能。阿尔茨海默病(AD)是一种神经退行性疾病,β - 淀粉样蛋白被认为是 AD 发病的关键分子[29],而核桃多酚具有降低 β - 淀粉样蛋白引起的 PC12 细胞的氧化应激、DNA 损伤、乳酸脱氢酶(LDH)释放、细胞凋亡等活性[30]。另外,核桃多酚还可以抑制帕金森病(PD)小鼠脑细胞中活性氧(ROS)和一氧化氮(NO)的产生,并减缓纹状体区多巴胺及其代谢产物的衰竭,具有预防或治疗帕金森病的潜力[31]。

2.5　预防或治疗糖尿病活性

糖尿病(DM)是机体内胰岛素相对或绝对不足所导致的代谢紊乱疾病,核桃多酚主要通过减轻氧化应激或抑制 α - 淀粉酶两种途径对糖尿病起到预防或治疗作用[32-33]。糖尿病的发生、发展过程与氧化应激密切相关,氧化应激会引发胰岛 β 细胞与线粒体功能障碍及胰岛素抵抗[33]。Fukuda 等[34]采用的 2 型糖尿病小鼠经核桃多酚干预后,能降低尿液中 8 - 羟基 - 2′ - 脱氧鸟苷(8 - hydroxy - 2′ - deoxyguanosine,8 - OHdG)的含量,从而可以减轻氧化应激反应。此外,碳水化合物水解酶——α - 淀粉酶在淀粉和糖原消化中起着重要作用,多酚可以与 α - 淀粉酶相关活性位点通过共价结合使其氨基酸侧链封闭从而抑制其活性,核桃多酚对 α - 淀粉酶的抑制率高达 60%,因而核桃多酚可通过限制或者延缓碳水化合物的分解降低机体对葡萄糖的吸收而起到治疗糖尿病的作用[32,35]。

2.6　其他生物活性

(1)抑制酪氨酸酶活性:酪氨酸酶是黑色素合成过程中的关键酶,而核桃多酚类物质,如鞣花酸、没食子酸、槲皮素等对酪氨酸酶均有抑制作用[36-37]。

(2)保护肝损伤活性:核桃多酚对酒精、*D* - 氨基半乳糖和四氯化碳诱导的肝损伤具有缓解作用[38-39]。

(3)抗菌活性:核桃多酚对多种细菌(芽孢杆菌、枯草杆菌、金黄色葡萄球菌、大肠杆菌、肺炎克雷伯菌等)、真菌(白色念珠菌、新型隐球菌等)、病毒(烟草花叶病毒)均具有较强的抑制活性[40-41]。

(4)缓解免疫毒性:脾脏是机体重要的免疫器官,核桃多酚可以恢复机体内脾淋巴细胞活力、T 细胞亚群数、T 细胞分泌细胞因子和颗粒酶的功能,并通过调节 Toll 样受体信号通路对有机磷农药、4 - 戊基苯酚、3 - 甲基 - 4 - 硝基苯酚等诱导的免疫毒性具有抑制作用[42-44]。

3　结　语

核桃多酚类物质种类丰富,具有多种生物活性,尤其是显著的抗氧化活性。然而,目前对核桃多酚的研究主要集中于实验室阶段,市面上核桃多酚相关的产品较少。对核桃多酚类物质多种生物活性及

机理的深入研究,可为其相关功能性产品的研发奠定理论基础。今后应重点研发适用于核桃多酚类物质工业化生产的工艺及配套设备,提高核桃加工过程中副产物的附加值。

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