

冬虫夏草的质量和功能研究进展*

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摘要 冬虫夏草 *Ophiocordyceps sinensis* 是名贵的药用与食用菌, 具有抗氧化、抗细菌、抗肿瘤及免疫调节等多种功能。冬虫夏草的正确鉴别、质量和功能评价有助于这一珍贵资源的研发。本文从如下方面综述冬虫夏草在质量和功能方面的研究进展: 1) 性状特征和真假鉴别; 2) 主要成分; 3) 药效功能; 4) 质量评价。

关键词 冬虫夏草, 性状特征, 真假鉴别, 主要成分, 质量评价

Progress in research on the quality and function of *Ophiocordyceps sinensis*

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Abstract *Ophiocordyceps sinensis* is a famous and valuable medicinal and edible mushroom with broad therapeutic antioxidant, antibacterial, anti-tumor, and immune stimulation, functions. Identification and evaluation of the quality and function of *O. sinensis* contributes to the research and development of this precious resource. This paper reviews progress in research on the quality and function of *O. sinensis* including its characteristics and identification, main components, pharmacological functions and quality evaluation.

Key words *Ophiocordyceps sinensis*, characteristic, identification, main components, evaluation of quality

冬虫夏草 *Ophiocordyceps sinensis* 属于子囊菌门 (Ascomycota), 粪壳菌纲 (Sordariomycetes), 肉座菌目 (Hypocreales), 线性虫草菌科 (Ophiocordycipitaceae), 线性虫草属 (*Ophiocordyceps*), 是冬虫夏草真菌寄生在蝙蝠科昆虫上形成的菌核和子座复合物 (Sung *et al.*, 2007; Yue *et al.*, 2013)。冬虫夏草是生长在青藏高原地区特有的物种, 全球仅分布在中国、不丹、印度、尼泊尔 4 国, 在我国主要分布在西藏、青海、四川、云南、甘肃等省 3 000~5 200 m 的高海拔地区 (Yue *et al.*, 2013)。

随着冬虫夏草的药效功能被证实, 国内外越来越关注冬虫夏草, 交易额呈增长的趋势 (Buenz *et al.*, 2005)。由于生境特殊、自然资源有限、价格昂贵, 冬虫夏草资源被过度采挖, 生态环境严重受损, 已濒临枯竭, 大部分地区的产量不到 25 年前的 10% (尹定华等, 2011)。然而, 人们对冬虫夏草的需求量日趋增多, 供不应求, 导致冬虫夏草的价格飙升。不法商贩为追求高额利润, 以假乱真、以次充好, 导致冬虫夏草市场出现混乱。本文论述冬虫夏草的性状特征和真假鉴别、主要成分、药效功能和质量评价等方面的研

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究概况,以期对冬虫夏草真假的鉴别和质量优劣的评价奠定基础。

1 冬虫夏草的性状特征和真假鉴别

1.1 冬虫夏草的性状特征

冬虫夏草的虫体部分似蚕,长 3~5 cm,直径 0.3~0.8 cm;表面深黄色至黄棕色,有环纹 20~30 个,近头部的环纹较细;头部红棕色,足 8 对,中部 4 对较明显,质脆,易折断,断面平坦,淡黄白色。子座部分细长圆柱形,长 4~7 cm,直径 0.2~0.4 cm;表面呈深棕色至棕褐色,有细纵皱纹,上部稍膨大,质柔韧,断面类白色。冬虫夏草气微腥,味微苦(康帅等,2013)。

1.2 冬虫夏草的混淆品与次品

1.2.1 偷换概念 冬虫夏草是线性虫草属的。其他品种的虫草如蛹虫草、凉山虫草、戴氏虫草等都不是真正的冬虫夏草,营养价值没有冬虫夏草高,有些虫草错误食用后对人体健康有害。

1.2.2 制造伪品 不法商贩用植物地蚕、石蚕、甘遂、甘露、僵蚕等冒充冬虫夏草的虫体,也有用淀粉、石膏、黄花菜等为原料人工模压、染色伪造冬虫夏草的虫体(徐如英,2010)。

1.2.3 黑心加重 不法商贩将冬虫夏草浸泡明矾水、饱和硫酸钾溶液或喷洒金属粉,或在冬虫夏草内部插入铁丝、铜丝,在子实体底部捏黑色泥粉、铁粉等以增加冬虫夏草的重量或让外观更漂亮(杨艳青和段军华,2012)。

1.2.4 以次充好 部分黑心商贩收购已经提取过有效成分的冬虫夏草次品,经过烘干、着色处理后将次品以高价卖出,愚弄消费者。劣质冬虫夏草气味极弱,虫体呈暗黄色,水洗或煎煮后褪色。

1.3 冬虫夏草的真假鉴别

1.3.1 形状鉴别 中国药典鉴别冬虫夏草真假主要通过观察样本的形状,包括虫体和子座的颜色、大小,足的数目,气味等。陈小秋等(2011)通过观察子座的有无、形状,虫体的颜色等特征区分冬虫夏草的真假。

1.3.2 显微鉴别 显微鉴别主要涉及对虫体进

行横切,观察虫体中央的结构,躯壳表皮有无着生绒毛、躯壳内有无菌丝等;对子座进行横切、纵切,观察子囊壳包埋位置,子囊壳及子囊孢子形态、大小等。

Au 等(2012)对香港市场上冬虫夏草和混淆品的虫体和子座进行横切面切割,制作成切片,观察子囊大小、着生的方式,复眼和体壁形状特征。康帅等(2013)对冬虫夏草及样本的虫体体壁和腹足进行切割,观察气门、气窝、趾的颜色、形状、大小,鉴别冬虫夏草的真假。

1.3.3 理化鉴别 目前,针对冬虫夏草的理化鉴别方法主要有:紫外吸收光谱法、红外光谱法、薄层色谱法、毛细管电泳法、蛋白电泳法、免疫分析鉴定法、高效液相色谱法和核磁共振图谱等。高明等(2011)发现冬虫夏草乙醇提取液在 269.00 nm 和 206.20 nm 波长处有最大紫外吸收峰,张声俊(2011)用红外光谱技术对比真假冬虫夏草的油脂、蛋白质和多糖的波峰。顾峥嵘和张全龙(2003)采用薄层层析法,发现冬虫夏草乙醇提取液与标准品显示出相同颜色的斑点。古今等(2005)用高效毛细管电泳法发现冬虫夏草的 Tris-甘氨酸蛋白提取液的最高峰迁移时间与混淆品存在明显的差异。徐君(2006)在蛋白电泳法中,利用扫描图谱进行聚类分析虫草类别。李扬(2013)在免疫分析鉴定方法中,制备冬虫夏草的抗原,用金标试纸法检测冬虫夏草真假。Wang 等(2013)用高效液相色谱法(High performance liquid chromatography, HPLC)测定冬虫夏草,发现尿苷、鸟苷、腺苷是冬虫夏草中重要核苷类物质。武彦舒等(2008)用 HPLC 构建核苷指纹图谱,运用聚类分析鉴别冬虫夏草的真假;Guan 等(2011)构建多糖指纹图谱,发现冬虫夏草中含甘露糖、葡萄糖、半乳糖,不含半乳糖醛酸。陈罡等(2014)采用核磁共振技术构建核磁特征指纹图谱,鉴别冬虫夏草真假。

1.3.4 分子鉴别 冬虫夏草是真菌子座与蝙蝠蛾科幼虫的复合体,可以运用分子生物学技术从真菌和昆虫两方面对冬虫夏草进行真假鉴别。

目前,ITS 序列分析技术已成功应用于真菌分类学研究中,该技术快速、准确、简便(Rehner

and Buckley, 2005; Stensrud *et al.*, 2005; Feng *et al.*, 2009)。翁榕安和李树华(2008)运用 ITS 序列分析技术,发现冬虫夏草和蛹虫草两者的 ITS 相似度远小于 90%,可以推断为不同的种。多数学者认为,ITS 序列具种属特异性,用以鉴定冬虫夏草中的多种菌物具有优势(魏鑫丽等, 2006; Xiao *et al.*, 2009; 张永杰等, 2010; Zhang *et al.*, 2010; 朱佳石和吴建勇, 2015)。

在真核生物中,细胞色素 c 氧化酶 CO 基因具有昆虫种属特异性,在一定程度上用于检测种、属间的进化关系(Flomer *et al.*, 1994; Hebert *et al.*, 2003)。细胞色素 b Cytb 基因是线粒体中结构和功能被研究最为清楚的基因之一,进化速率适中,被用于研究种类遗传分化程度和系统进化(程舟等, 2007)。冬虫夏草真假的鉴别方法见表 1。

表 1 冬虫夏草的真假鉴别
Tabel 1 Identification of *Ophiocordyceps sinensis*

鉴别类型 Identifying type	鉴别参数或方法 Identification parameters or methods
形状鉴别	虫体和子座的颜色、大小,足的数目,气味等
显微鉴别	虫体切片:观察躯壳内绒毛和菌丝,体壁和腹足结构; 子座切片:观察子囊壳包埋位置,子囊壳及子囊孢子形态、大小等
理化鉴别	紫外吸收光谱法、红外光谱法、薄层色谱法、毛细管电泳法、 蛋白电泳法、免疫分析鉴定法、高效液相色谱法和核磁共振图谱
分子鉴别	冬虫夏草菌 ITS 序列分析,虫体 CO 和 Cytb 序列分析

2 冬虫夏草的主要成分

2.1 核苷类

核苷类物质是冬虫夏草中的重要生物活性成分,冬虫夏草含腺嘌呤、腺苷、鸟苷、尿嘧啶和胞嘧啶等核苷成分(Yu *et al.*, 2006; Zhao *et al.*, 2014)。核苷物质在中枢神经系统等多种生理活动中发挥着重要的作用(Li *et al.*, 2006),其中腺苷具有促进细胞分化、改善心脑血管血液循环、抑制蛋白质激酶和反转录酶活性等功能(Omar *et al.*, 2012; Niccoli *et al.*, 2013)。产地不同,冬虫夏草的核苷成分的组成与含量有所不同(夏文娟等, 2001; 肖远灿等, 2014);冬虫夏草的不同部位,其核苷成分也有差异(Ikeda *et al.*, 2008)。在核苷类物质中,腺苷、肌苷含量相对较高、稳定,可以作为冬虫夏草质量控制的指标。2010 年版的《中华人民共和国药典》把腺苷含量定为冬虫夏草的含量测定项目,规定冬虫夏草的腺苷含量不得少于 0.01%。

2.2 多糖类

多糖为冬虫夏草中含量高的药理活性物质,

冬虫夏草干品中多糖含量约为 3%~8%(Li *et al.*, 2001)。冬虫夏草在生长过程中,会产生大量的胞外多糖(Extracellular polysaccharides, EPS)和胞内多糖(Intracellular polysaccharides, IPS),由葡萄糖、甘露糖、半乳糖、木糖等单糖通过糖苷键形成直连、支链构成多糖(Cheung *et al.*, 2009)。冬虫夏草菌培养液分离出的 EPS 分子量大小为 5~200 ku,具有抗氧化、刺激多种细胞因子释放、延缓肾衰竭的作用(Yan *et al.*, 2009; Wang *et al.*, 2010, 2011)。冬虫夏草菌丝分离出的 IPS 分子量大小为 8.1~460 ku,具有抗氧化、降低胆固醇活性(Li *et al.*, 2003; Wang *et al.*, 2009; Kim, 2010)。真菌多糖是一种 β -型多糖,具有螺旋的三维立体结构,近似 DNA。多糖的抗肿瘤活性与多糖的分子量有关,分子量大于 1.6×10^6 时才具有抗肿瘤活性(Sasaki *et al.*, 1976)。多糖的活性除了与分子量有关外,还与多糖的溶解度、黏度、初级结构和高级结构有关。通过对多糖的酶解、色谱分析,多糖的组成和键的结构等指纹图谱构建出来,作为冬虫夏草质量控制的指标(Guan and Li, 2010)。

2.3 甾醇类

甾醇类化合物是真菌细胞膜的重要组成部分,同时还具有多种生物学活性(Volkman, 2003)。从冬虫夏草有机物提取液中可分离出胆甾醇、 β -谷甾醇、啤酒甾醇、麦角甾醇、麦角甾醇过氧化物(郇皆秀等, 2003)。麦角甾醇是冬虫夏草内主要甾醇,是维生素 D₂ 的重要前体,具有利抗癌、抑菌、抗纤维化、抑制抗药性等功能(Yan *et al.*, 2009; Hu *et al.*, 2014; Zhu *et al.*, 2014)。麦角甾醇可分为游离麦角甾醇和酯化麦角甾醇,野生冬虫夏草的虫体和子座中同时具有这两种成分,虫体酯化的麦角甾醇含量高于子座中的含量。麦角甾醇含量在冬虫夏草内相对稳定,可以作为冬虫夏草质量控制的指标(Yuan *et al.*, 2007)。

2.4 虫草酸

虫草酸又称 D-甘露醇,为奎宁酸的一种异构体(Sprecher and Sprinson, 1963),是冬虫夏草中的主要有效成分之一,具有降低脑血容量、利尿脱水、抗自由基、镇喘祛痰、促进消化等药理作用,对多种疾病有一定的疗效(陈洁丽等, 1997; Hanieh and Sakaguchi, 2009; Daviskas *et al.*, 2010; Diringier *et al.*, 2012; Min *et al.*, 2013)。冬虫夏草的虫草酸干重含量高于 3.4%,一般子座中的虫草酸含量约 29~85 mg/g。虫草酸含量随冬虫夏草子座发育成熟度增加而增加,同时与产地、寄主、生长期有关(蔡仲军, 2003)。虫草酸含量高低常被作为衡量冬虫夏草质量的重要指标。

2.5 氨基酸和蛋白质

冬虫夏草中含丰富的氨基酸和蛋白质,蛋白质的含量约 29.1%~33%。氨基酸有蛋氨酸、亮氨酸、谷氨酸、天冬氨酸、精氨酸、甘氨酸和酪氨酸等 18 种。水解后的氨基酸含量一般在 20%~25%,冬虫夏草菌丝中 3 种主要氨基酸分别是谷氨酸、天冬氨酸、赖氨酸,野生冬虫夏草中 3 种主要氨基酸分别是谷氨酸、天冬氨酸、精氨酸(Hsu *et al.*, 2002; Zhou *et al.*, 2009)。严冬和杨鑫堃(2014)通过比较发现西藏不同产地野生冬虫夏草的氨基酸种类和含量无显著性差

异,必需氨基酸相对均衡和合理。冬虫夏草丰富的氨基酸与家禽肉食互补,可提高营养价值,改善人体状况(钱爱萍等, 2010)。冬虫夏草的多肽具有抗氧化、抗癌细胞和治疗脑缺血再灌注损伤等功能(Jia *et al.*, 2005; Wang *et al.*, 2012)。

2.6 野生冬虫夏草和人工培养的冬虫夏草菌粉的活性成分含量比较

不少学者分析比较了野生冬虫夏草和人工培养的冬虫夏草菌粉的多种活性成分含量。数据库公布的部分冬虫夏草菌序列是不可靠的,可能原因是使用的研究材料不可靠或不明确,适于在低于 21℃ 下生长和生长缓慢是冬虫夏草菌的重要特征(Dong and Yao, 2011)。Li 等(2006)测定深层培养的冬虫夏草菌丝中核苷类(腺苷、鸟苷、尿嘧啶和肌苷)含量为 6.20 mg/g,振荡培养的冬虫夏草菌丝中核苷类含量为 1.60 mg/g,野生冬虫夏草子实体中核苷类含量为 1.80 mg/g。Hsu 等(2002)测定冬虫夏草发酵菌丝中甘露醇含量超过 7.99%,多糖主要由甘露糖、葡萄糖和半乳糖等以 1.00:3.82~16.61:1.28~1.60 摩尔比构成;冬虫夏草菌丝中甘露糖含量低于 5.83%,多糖主要由甘露糖、葡萄糖和半乳糖以 1.00:1.09~3.01:1.05~3.30 摩尔比构成。Li 等(2004)测定冬虫夏草菌丝中游离麦角甾醇含量为 2.71~3.23 mg/g,野生冬虫夏草中游离麦角甾醇含量为 0.97~1.43 mg/g。Wang 等(2009)测定冬虫夏草菌丝因受产地和培养方式等因素影响,冬虫夏草菌丝中虫草酸含量波动较大,为 3.17~82.07 mg/g,野生冬虫夏草中虫草酸含量为 89.77~91.80 mg/g。Hsu 等(2002)测定冬虫夏草发酵菌丝中氨基酸含量为 9.23%,其中谷氨酸含量为 1.12%,天冬氨酸含量为 1.05%,赖氨酸含量为 0.80%;野生冬虫夏草中氨基酸含量为 18.1%,其中谷氨酸含量为 2.64%~2.66%,天冬氨酸含量为 1.70%~1.84%,精氨酸含量为 1.53%~1.60%。

3 冬虫夏草的药理作用

3.1 抗氧化

冬虫夏草的水分提取液和乙醇提取液具有

高效的抗氧化活性,可抑制羟基自由基诱导形成的丙二醛,抑制脂质过氧化和低密度脂蛋白氧化,减少胆固醇酯在巨噬细胞内的积累(Yamaguchi *et al.*, 2000a, 2000b)。有学者采用黄嘌呤氧化实验、溶血诱导实验、脂质过氧化实验 3 种不同实验方法分析冬虫夏草水分提取液的抗氧化活性,结果证实冬虫夏草具有高效的抗氧化活性(Li *et al.*, 2001)。冬虫夏草菌丝中分离出的 1-(5-hydroxymethyl-2-furyl)- β -carbolin 对超氧离子具有较强的抑制活性,半数效应浓度(The half maximal inhibiting concentration IC_{50})为 $(0.45 \pm 0.15) \mu\text{mol/L}$ (Yang *et al.*, 2011);冬虫夏草发酵液中分离出的黑色素具有较强的 DPPH (1,1-diphenyl-2-picrylhydrazyl) 自由基清除活性和螯合亚铁离子的活性(Dong and Yao, 2012);冬虫夏草菌丝水提取液中含有高量的酚类和黄酮类化合物,与清除 DPPH 自由基和还原三价铁离子等活性密切相关(Rathor *et al.*, 2014)。赵聃聃等(2015)研究发现冬虫夏草菌丝多种有机溶剂提取液具有清除自由基的还原力,其抗氧化活性物质多集中在中极性部位。

3.2 抗菌

冬虫夏草的抗菌物质具有广谱性,对原核生物中的革兰氏阴性菌(如大肠埃希菌)和阳性菌(如金黄色葡萄球菌)、芽孢杆菌(如枯草芽孢杆菌、苏云金芽孢杆菌)和非芽孢杆菌(如鼻疽杆菌)、放线菌(如链霉菌)均有拮抗性,但对酵母和丝状真菌没有抗菌活性(程显好和白毓谦, 1995; 武忠伟等, 2008)。董开忠等(2014)用头孢曲松钠溶液诱导小鼠菌群失调,冬虫夏草菌丝可能通过调节血清血管活性肠肽和 P 物质含量来调整菌群失调小鼠肠道内有益菌的比例。

3.3 抗肿瘤

冬虫夏草提取物在体外具有明显地抑制、杀伤肿瘤细胞的活性,其中核苷类(衍生物)、甾醇类和多糖类与抗肿瘤活性有关。Wu 等(2007)发现冬虫夏草菌丝的乙酸乙酯提取液对小鼠黑色素瘤细胞具有抑制作用;Matsuda 等(2009)

证实以甲醇和乙酸乙酯从冬虫夏草菌丝体分离出的多种甾醇类化合物具有抗早幼白血病 HL-60 癌细胞的活性。Aghaei 等(2012)和 Otsuki 等(2012)发现腺苷能上调抑癌基因 p53 的表达,阻滞细胞周期的进展,诱导癌细胞发生凋亡。Mei 等(2014)从冬虫夏草分离了一种能抑制肉瘤细胞增殖的杂多糖,在一定浓度下能诱导肉瘤细胞的凋亡。罗小平等(2012)以肿瘤移植成功的大白兔为模型,证实了野生冬虫夏草水溶液抑制兔肝内部肿瘤细胞的生长,减少肿瘤细胞转移的发生率。冬虫夏草抗肿瘤细胞机制可能涉及到:直接的细胞毒性,诱导肿瘤细胞发生凋亡,激活或增强免疫功能(Zhang and Wu, 2007; Zhao *et al.*, 2011; Chen *et al.*, 2012)。

3.4 降血糖和降血脂

冬虫夏草主要通过刺激胰岛素分泌、抑制肝葡萄糖输出、促进肝脏葡萄糖代谢酶活力和降低葡萄糖转运蛋白含量等来达到降低血糖的作用,而且只有血糖值高于正常时才有效(赵可蕊等, 2006)。研究者用链脲佐菌素和肾上腺素诱导小鼠产生糖尿病,通过注射、口服冬虫夏草提取液等方式增加肝葡萄糖激酶、己糖激酶、葡萄糖磷酸脱氢酶等活性,降低血糖的浓度,但正常小鼠的胰岛素含量没有受到影响(Kiho *et al.*, 1993, 1999)。

在给小鼠喂高脂食物时,通过口服冬虫夏草提取液能增加血清的脂肪氧化,增加高密度脂蛋白的胆固醇水平、减少极低密度脂蛋白和低密度蛋白的胆固醇水平,从而达到降低血浆中胆固醇水平(Koh *et al.*, 2003; Yamaguchi *et al.*, 2000b)。

3.5 保护肝和肾

动物测试和临床实验证实冬虫夏草具有保肝作用,麦角甾醇和多糖是保护肝脏的活性物质。在 CCl_4 诱导的急性肝损伤小鼠中,冬虫夏草菌丝提取液能减轻肝细胞坏死程度,对化学性肝损伤有辅助保护功能(杨槐俊等, 2013)。同时,冬虫夏草提取液能减轻肝脏炎症,减少胶原沉积,还能防止肝纤维化(Peng *et al.*, 2014)。

在二甲基亚硝胺诱导的大鼠肝纤维化模型中,冬虫夏草制剂(百令肝胶囊)能促进损伤细胞再生,降低肝纤维化面积,从而起到减缓肝纤维化进程和恢复肝脏功能的作用(钱莺等,2013)。

中药理论认为冬虫夏草具有补肾的功能,研究发现冬虫夏草补肾功能来自于增加体内的17-羟基-皮质类固醇和17-酮-类固醇(Zhu *et al.*, 1998)。患有糖尿病大鼠的肾脏是慢性缺氧的,缺氧诱导因子(Hypoxia inducible factor-1 α , HIF-1 α)和血管表皮生长因子(Vascular endothelial growth factor, VEGF)表达量是高于正常大鼠的。研究发现冬虫夏草通过降低HIF-1 α 和VEGF表达量来治疗慢性缺氧损伤(袁明霞等,2013)。在糖尿病肾病或肾缺血-再灌注大鼠模型中,冬虫夏草和冬虫夏草制剂(金水宝)降低蛋白尿含量,减轻肾小管损伤,对肾具有保护作用(黄可等,2014;张莉等,2014)。施海涛等(2013)研究发现金水宝能降低糖尿病肾病患者转化生长因子表达量,延缓肾小球硬化。在肾移植患者中,Ding等(2011)结合使用环孢菌素A和冬虫夏草制剂(百令胶囊)能减少急性排斥反应、病症并发症。

在临床中,冬虫夏草和其他一些药物结合起来使用治疗肝病和肾病,其治疗效果显著地高于使用单一药物(Ahmed *et al.*, 2012)。

3.6 对呼吸系统的作用

冬虫夏草能增强肾上腺素,扩张支气管炎,松弛支气管平滑肌,后延哮喘发作时间,减轻老年肺气肿、肺心病、慢性哮喘症状,延缓复发时间,起到止咳平喘作用。魏涛等(2002)选用二月龄小鼠作为研究对象,结果发现冬虫夏草菌丝体能降低浓氨水致咳小鼠的咳嗽次数,延长咳嗽潜伏期。在Sprague Dawley大鼠急性支气管哮喘模型中,金水宝抑制炎症细胞及炎症因子在肺内聚集,缓解哮喘症状(郭之强和颜春松,2011)。钱皓瑜(2004)在临床试验中,证实冬虫夏草能显著改善慢性阻塞性肺疾病(Chronic obstructive pulmonary disease, COPD)患者肺通气功能,提高血氧分压,降低血浆内皮素。孙雯等(2010)

研究发现冬虫夏草菌粉提取液能减少哮喘儿童哮喘过程中炎症蛋白的过度表达,减轻炎症反应。冬虫夏草对肺功能的保护作用可能是通过降低气道炎症反应,减少支气管肺泡灌洗液中的基质金属蛋白酶-9的表达而实现的(管彩虹等,2013)。

3.7 对心血管系统的作用

冬虫夏草对心血管系统的作用主要表现在:降低血压、减慢心率,增强心肌耐缺氧能力,抗心律失常,抑制血小板聚集,调节血脂平衡等。

当用冬虫夏草煎剂给高血压大鼠灌胃,能明显降低大鼠血压,并且逆转肾性高血压时所发生的心肌肥大(吴秀香等,2001)。当以Brown Norway大鼠作为研究模型时,冬虫夏草提取液能降低大鼠血管平滑肌的增殖能力,降低动脉硬化化的形成,有助于器官的移植(Zhang *et al.*, 2012)。金水宝可以降低炎症反应,有效改善肺心病患者的血管内皮功能和左室舒张功能(张晓斌等,2012);百令胶囊能明显改善维持性血液透析(Maintenance hemodialysis, MHD)患者的体内氧化应激水平,减少心脑血管事件的发生率(王英,2013)。也有学者发现,从冬虫夏草菌丝分离的一种水溶性多糖能抑制细胞内部信号和血小板激活,对于治疗心血管疾病具有潜在的应用价值(Lu *et al.*, 2014)。

3.8 调节免疫

冬虫夏草对多种疾病的防治发挥着重要的药理作用,对免疫功能起着双向调节作用。Li等(2009)发现野生冬虫夏草水分提取液通过树突细胞调节辅助T细胞Th1/Th2比例来调节免疫反应。冬虫夏草菌丝体分离出来的胞外多糖对小鼠体内的癌细胞具有抑制作用,同时提高腹腔巨噬细胞的吞噬能力,提高淋巴细胞的繁殖能力,显著地提高免疫能力(Zhang *et al.*, 2008; Yue *et al.*, 2013)。Wu等(2014)从冬虫夏草中提取多糖-cordysinan,它对巨噬细胞没有副作用,可刺激巨噬细胞分泌细胞因子和趋化因子,促进免疫细胞参与免疫应答。通过向培养基添加冬虫夏草菌

丝提取液,能增加多种细胞因子的表达、分泌,消除外毒素 B 的抑制作用 (Kuo *et al.*, 2007)。冬虫夏草内多种活性物质在细胞免疫和细胞因子等方面协同参与提高免疫功能 (Zhou *et al.*, 2008)。

4 冬虫夏草质量优劣的评价

冬虫夏草作为中国传统的名贵中草药,具有多种药效活性。多年来,科学工作者证实冬虫夏草具有抗氧化、抗菌、抗癌细胞和调节免疫等功效。国内的冬虫夏草品种繁多,有青海草、川草、藏草和滇草等之称,其质量优劣的评价一直存在着争议。部分人士以单株虫草质量重、虫草饱满和虫草干者为优,这种评价方式易受主客观因素影响,难以让人信服。

目前,我国中药质量评价基本上属于“唯成分论”的评价模式。这种评价模式是参照国外天然药物的质量控制方法,借鉴化学药品质量控制的模式建立的。Guo 等 (2006) 结合使用 HPLC 和质谱检测 (Mass spectrometric, MS) 技术,测定发现四川野生冬虫夏草中核苷类含量最多。陈婷等 (2013) 用 HPLC 同时测定西藏那曲、青海玉树、四川康定、云南迪庆和甘肃甘南野生冬虫夏草样品中腺苷和麦角甾醇含量,发现青海玉树、西藏那曲样品中腺苷和麦角甾醇含量较高。将各地区野生冬虫夏草中氨基酸含量进行比对分析,发现青海和西藏冬虫夏草中的氨基酸含量低于四川和云南冬虫夏草 (于斌等, 2012)。

对于冬虫夏草这种中草药,只检测其中几种活性成分不能反映其所体现的整体疗效,难以有效、全面地监控和评价。随着研究工作的深入,这种质量评价模式逐渐显现弊端,遇到更多的挑战 (Xiao *et al.*, 2013)。2010 年版《中国药典》明确提出中药的质量标准逐步由单一指标成分定性定量测定,向活性有效成分及生物测定的综合检测过渡。因此,科学家研究并建立中药生物效价检测的方法,控制其质量。

冬虫夏草中含有腺苷、肌苷、麦角甾醇、虫草酸和多糖 5 种活性成分,含量较高且稳定,具

有有多种药用功效。对于冬虫夏草而言,可将形态、活性成分和药理活性结合从多角度对其质量作出评价。Li 等 (2001) 研究发现人工培养的冬虫夏草菌丝和野生冬虫夏草具有相似的抗氧化能力。张巧霞等 (2005) 发现人工培养的冬虫夏草菌丝和野生冬虫夏草有机溶剂提取物能抑制小鼠黑色素瘤细胞 B16,人工培养菌丝的抑制效果优于野生冬虫夏草。孙超等 (2015) 结合形态、分子鉴别方法,对采自青海、四川、西藏和云南的野生冬虫夏草样品进行了质量参数测定,结果所采集的样品均为冬虫夏草;4 种样品的虫草酸和多糖含量均高于腺苷、肌苷和麦角甾醇含量;以上 5 种活性成分含量,云南和青海冬虫夏草均高于西藏和四川冬虫夏草;在清除 DPPH 自由基活性方面,云南和西藏冬虫夏草则高于青海和四川冬虫夏草;而在抑制 MT-1 活性上不同产地的冬虫夏草差异不显著。

5 展望

目前,冬虫夏草被列为国家二级保护物种,资源的枯竭和需求的旺盛导致了其价格的飞涨。市场上出现的某些假冒冬虫夏草产品严重影响了消费者的利益。本文在综述了关于冬虫夏草最新研究成果的基础上认为,规范冬虫夏草生产与销售市场的管理制度,加强冬虫夏草的规模化繁殖技术研究,鼓励在原产地建立冬虫夏草产业基地,是解决当前冬虫夏草供需矛盾的必由之路。

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