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初榨椰子油的营养组分和功效作用研究进展

雷昌贵[1],孟宇竹[2*],陈锦屏[3],张晓东[2],蔡花真[1],张旭伟[1]
(1.河南质量工程职业学院食品与化工学院,河南 平顶山,467000;
2.平顶山技师学院现代服务系,河南 平顶山,467000;
3.陕西师范大学食品工程与营养科学学院,陕西 西安,710119)

摘要:初榨椰子油(virgin coconut oil,VCO)是中链脂肪酸的主要来源之一,其中月桂酸的含量达到总脂肪酸的44%~54%。随着研究的不断深入,VCO越来越受到食品及医药领域的关注,其市场规模也在逐年扩大。本文介绍了VCO的营养组分和理化性质,对其所发挥的抗氧化、抗病毒、抗菌和预防心血管疾病等健康功效及其潜在机制进行了综述,为VCO的进一步开发与推广提供理论参考。

关键词:初榨椰子油;营养组分;理化性质;健康功效;活性机制
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Research progress on nutrient components and bioactivities of virgin coconut oil

LEI Chang-gui[1], Meng Yu-zhu[2*], CHEN Jin-ping[3], ZHANG Xiao-dong[2], CAI Hua-zhen[1], ZHANG Xu-wei[1]
(1. *Henan Quality Polytechnic, Food and Chemical Engineering Department, Pingdingshan* 467000, *China*; 2. *Pingdingshan Institute Technology, Modern Service Department, Pingdingshan* 467000, *China*; 3. *Shanxi Normal University, College of Food Engineering and Nutritional Science, Xi'an* 710062, *China*)

Abstract: Virgin coconut oil is a valuable source of medium chain fatty acids, with lauric acid comprising 44%-54% of the total fatty acids. With the deepening of research, virgin coconut oil has attracted growing attention in the field of food and medicine. Besides, its market scale is also expanding year by year. In this article, the nutrient components and physicochemical properties of VCO were introduced, and the health effects of VCO on antioxidant, antiviral, antibacterial and cardiovascular disease prevention and their potential mechanisms were reviewed. It was aimed to provide theoretical reference for the further development and popularization of virgin coconut oil.

Key words: virgin coconut oil; nutrient component; physicochemical property; health benefit; bioactive mechanism

椰子树(*Cocos nucifera* L.)属于棕榈科(Palmae),是世界上最重要的热带作物之一,它为人类提供了大量有价值的产品,对种植地经济和文化的发展起着重要作用,被不同国家和地区称为"生命之树"。全球椰子树的种植面积约1300万公顷,主要分布在印度、菲律宾、印度尼西亚、巴西、斯里兰卡和中国在内的90多个国家和地区[1]。国际组织亚太椰子共同体(Asia-pacific Coconut Community,APCC)将椰子油细分为椰子原油(crude coconut oil,CCO)、精炼椰子油(refined coconut oil,RCO)和初榨椰子油(virgin coconut oil,VCO)[2]。CCO是通过压榨或浸提工艺从椰肉中制取的非食用油脂,由于其中所含杂质较多,酸值高、口感差,一般作为化工业配料[3]。RCO是以椰子的干胚乳为原料,经过一系列的化学精制而得到的椰子油,精炼工艺一方面降低了原油的酸值,改善了油品的口感和风味,但本身存在的营养物质大量流失,它常被用于日化工业[4]。而VCO是从新鲜成熟的椰子胚乳中提取的食用油脂,由于不经过脱胶、脱酸和脱臭等化学精炼流程,不仅具有椰香味浓郁、色泽清亮、口感醇厚等优势,

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作者简介:雷昌贵(1981-),男,副教授,硕士,研究方向为食品加工与检测,E-mail: yzydyyzfhswh@163.com
* 通讯作者:孟宇竹(1982-),女,副教授,硕士,研究方向为农产品深加工与资源开发利用,E-mail: mengyuzhudb@163.com

还保留了含量较高的生育酚、植物甾醇和多酚等营养成分,除了能够直接用于食物的烹饪,还在烘焙食品、糖果制品和婴幼儿食品等领域广泛应用,被誉为最受欢迎的功能性食品之一[5,6]。

VCO是中链脂肪酸(medium-chain fatty acids,MCFA)(如辛酸、癸酸和月桂酸)的天然来源,占总脂肪酸64%[7],这使得VCO具有一些特殊的营养功效,包括抗病毒、抗菌、抗氧化、抗炎症等[8~10]。MCFA中的月桂酸占总脂肪酸44%~54%,它是一种低分子量的饱和脂肪酸,有助于提高高密度脂蛋白胆固醇水平,在抗肥胖治疗方面也具有潜在的应用价值[11]。近年来,VCO的健康特性受到了越来越多的关注,本文通过概述VCO的营养组分及其所发挥的健康功效,为VCO在生物医药和保健食品中的广泛应用提供理论支撑。

1 初榨椰子油的营养组分

1.1 初榨椰子油的脂肪酸组成

大量研究报道VCO中的脂肪酸以饱和脂肪酸为主(87.90%~95.10%),不饱和脂肪酸比例很低(~7.3%),保证了它的氧化稳定性。表1所示为采用不同提取方法制备的VCO脂肪酸组成及含量,数据显示VCO的脂肪酸组成均符合APCC和CAC规定的关于椰子油的标准,不同提取方法造成的脂肪酸含量主要是由于提取过程中的工艺参数不同所导致的。VCO中饱和脂肪酸的主要成分是位于sn-1或sn-3位置的MCFA,占比超过55%,其中包括辛酸(C8:0)、癸酸(C10:0)和月桂酸(C12:0),与其他植物油中普遍存在的长链脂肪酸相比,MCFA具有更小的分子尺寸和更低的熔点,可被肠道直接吸收,并被输送到肝脏作为能量来源,而不是以脂肪的形式储存起来[12,13]。月桂酸(C12:0)是存在于VCO中的主要MCFA,占总脂肪酸的44%~50%,它是VCO发挥抗菌、抗病毒活性,预防心血管疾病的主要活性组分之一,其次是肉豆蔻酸(C14:0)和棕榈酸(C16:0),分别占比18%~21%、7%~14%。

1.2 初榨椰子油中其他活性物质

除了含有丰富的月桂酸等MCFA之外,VCO中还有其他生物活性物质,其中包括酚类物质、生育酚、植物甾醇等,表2列举了利用热处理法和冷处理法提取的VCO中活性物质与RCO中的活性物质比较。酚类物质是VCO中存在的另一类主要的生物活性化合物,主要包括香豆酸、阿魏酸、咖啡酸、槲皮素和儿茶素等,它会对VCO的储存稳定性、感官品质和营养特性产生显著影响[18]。由于酚类物质具有抗氧化、抗炎症和降血脂等活性,也赋予了VCO多项药理潜力,使其被列为一种兼具抗氧化和抗炎作用的食用油和一种以植物化学物为基础的天然抗氧化剂。表2显示,热处理法制备的VCO中总酚含量明显高于冷处理法,其原因在于随着温度的升高,椰肉组织细胞中越来越多的酚类物质释放出来[19],而RCO经历了一系列精炼过程,大量酚类物质损失或降解。与此类似,Illam等[20]分别测定了利用热处理法和发酵法提取的VCO中总酚含量,发现两种方法制备的VCO中总酚含量分别为40.03±5.8 μg/mL和25.55±5.8 μg/mL。生育酚是存在于大多数植物油中的一种脂溶性天然抗氧化剂,可以防止油脂的自动氧化。它主要存在于椰子种皮上,在VCO制取过程中,椰子种皮是被剔除的,因此VCO中生育酚含量并不高,明显低于橄榄油(180 μg/g)、葵花籽油(630 μg/g)和玉米油(660 μg/g)[21]。植物甾醇属于类胆固醇分子,在肠道内仅被少量吸收,并抑制肠道胆固醇的吸收,具有降胆固醇和预防心血管疾病风险的潜在优势,在VCO中植物甾醇含量102.79 mg/100 g,但其含量与大豆油(900 mg/100 g)、玉米油(871 mg/100 g)和橄榄油(283 mg/100 g)相比仍有差距[7]。

2 初榨椰子油的理化性质

目前对VCO的理化性质研究主要集中于折光指数、酸价、碘价、过氧化值、皂化值和水分含量等方面。这些指标能够大致反映VCO中的脂肪酸组成、氧化稳定性以及是否存在杂质等情况,利用不同方法提取的VCO的理化指标如表3所示。VCO的折光指数(1.45)反映了脂肪酸的不饱和程度和平均链长[24],其值与大豆油(1.477)、葵籽油(1.467)和菜籽油(1.466)相当[25],不同提取方法制备的VCO的折光指数没有显著差异,说明各VCO样品均具有类似的饱和程度。酸价代表油中游离脂肪酸的含量,能够反映油脂的变质程度,椰子的酸价(0.32~0.40 mg KOH/g)明显低于大豆油(1.72 mg KOH/g)[26],而过氧化值揭示了油脂氧化初期形成的过氧化物和氢过氧化物的浓度,它也能反映油脂的稳定性[27],VCO的过氧化值明显低于CAC规定的油脂的过氧化值(10 meq O_2/kg),这说明VCO具有较好的储藏稳定性。碘价用于测定油脂中的不饱和程度,VCO的碘价(4.17~7.13 g I_2/100 g)均在CAC的限量标准范围内,较低水平的碘价说明了VCO具有较

表1 不同提取方法制备的VCO脂肪酸组成及含量[14-17]

Table 1 Composition and content of VCO fatty acids obtained by different extraction methods

脂肪酸 Fatty acid /%	湿磨法 Wet milling	干榨法 Expression	热处理法 Heat treatment	冷处理法 Cold treatment	酶法 Enzyme treatment	发酵法 Fermentation	冻融法 Chilling and thawing	精炼椰子油 Refined coconut oil	APCC标准 APCC standard	CAC标准 CAC standard
辛酸 Caprylic acid	5.60±0.70b	4.30±2.40a	6.80±0.10c	7.10±1.01c	6.60±0.10c	7.64±0.01d	7.50±0.02d	6.30±0.10c	5.00-10.00	4.60-10.00
癸酸 Decylic acid	5.00±1.00a	5.10±0.10a	5.80±0.30a	5.55±0.82a	5.90±0.20a	6.18±0.01a	6.01±0.01a	5.50±0.20a	4.50-8.00	5.00-8.00
月桂酸 Lauric acid	44.40±4.50a	44.70±0.60a	47.90±1.70a	50.00±0.11a	47.90±1.50a	47.95±0.01a	48.24±0.01a	47.10±1.10a	43.00-53.00	45.10-53.20
肉豆蔻酸 Myristic acid	21.20±4.20c	18.20±0.30a	19.30±1.50b	18.01±0.93a	20.40±0.50c	18.58±0.01a	18.85±0.01a	19.70±0.30b	16.00-21.00	16.80-21.00
棕榈酸 Palmitic acid	14.20±0.50e	12.30±0.50d	9.80±0.90b	7.05±0.81a	10.80±0.50c	9.04±0.00b	8.99±0.00b	10.20±0.30c	7.50-10.00	7.50-10.20
硬脂酸 Stearic acid	3.60±0.20b	3.10±0.10b	3.30±0.00b	2.42±0.01a	3.60±0.20b	3.16±0.20b	3.10±0.00b	3.20±0.20b	2.00-4.00	2.00-4.00
油酸 Oleic acid	6.10±1.10c	9.30±0.20e	5.70±0.40b	7.26±1.02d	4.00±0.10a	6.07±0.00c	6.08±0.01c	6.50±0.40c	5.00-10.00	5.00-10.00
亚油酸 Linoleic acid	1.70±0.10a	2.40±0.40a	1.60±0.20a	1.66±0.31a	1.40±0.70a	1.38±0.00a	1.23±0.00a	1.50±0.20a	1.00-2.50	1.00-2.50
饱和脂肪酸 Saturated fatty acid	94.00±2.50a	87.90±1.00a	92.70±0.20a	-	95.10±3.30a	-	-	92.00±0.60a	-	-
不饱和脂肪酸 Unsaturated fatty acid	7.90±1.00a	11.60±0.30b	7.30±0.20a	-	-	-	-	8.00±0.60a	-	-

注:CAC,食品法典委员会;含有完全不同小写字母的各组间有显著差异(P<0.05)

Note: CAC, Codex Alimentarius Commission; Different lowercase letters indicate significant difference (P<0.05)

表2 不同提取方法制备的VCO中其他活性物质的含量[14,22,23]

Table 2 Content of other bioactive compositions present in VCO obtained by different extraction methods

营养组分 Nutrient component	热处理法 Heat treatment	冷处理法 Cold treatment	精炼椰子油 Refined coconut oil
总酚 Total phenols /(μg/g)	650.35±25.11a	401.23±20.11b	182.82±15.24c
没食子酸 Gallic acid	25.29±1.11a	18.01±1.16b	1.06±0.05c
阿魏酸 Ferulic acid	12.83±0.94a	2.36±0.32b	ND
儿茶酸 Catechin	18.15±0.93a	12.35±1.03b	0.21±0.02c
绿原酸 Chlorogenic acid	1.55±0.11	ND	ND
表儿茶酸 Epicatechin	2.62±0.24	ND	ND
咖啡酸 Caffeic acid	1.59±0.12	ND	ND
香草酸 Vanillic acid	1.80±0.09a	1.03±0.06b	ND
对香豆酸 *p*-Coumaric acid	0.53±0.06	ND	ND
芥子酸 Sinapic acid	3.35±0.13a	1.89±0.14b	ND
槲皮素 Quercetin	1.62±0.09	ND	ND
生育酚 Tocopherol /(μg/g)	17.87±2.11a	27.65±3.09b	3.72±1.02c
植物甾醇 Phytosterol /(mg/100 g)	99.24±0.00b	102.79±0.00a	81.4±1.8c

注:ND,代表未检出;含有完全不同小写字母的各组间有显著差异(P<0.05)

Note: ND represents not checked; Different lowercase letters indicate significant difference (P<0.05)

高的饱和程度,对于增加油脂抗氧化酸败的能力有益[17]。水分含量也是影响VCO品质的主要因素之一,表3显示利用干榨法制备的VCO具有较低的水分含量,由于制备工艺是在干燥的环境下进行的,避免了过多水分残留在油品之中[27]。而RCO的水分含量(0.17%)则明显高于VCO,较高的水分含量势必会提高油脂的水解和氧化水平,增加游离脂肪酸含量,缩短油脂的货架期[28]。

3 初榨椰子油的保健功效

3.1 抗氧化和抗炎症作用

机体内过多的自由基会改变蛋白质、脂质和DNA等生物分子,并引发氧化应激,加速人体的衰老和各类器官组织的病变[7]。VCO中存在的多酚类物质、生育酚、植物甾醇和角鲨烯等生物活性物质是其具有抗氧化活性的基础,这些成分使得VCO在提高机体抗氧化状态,降低脂质过氧化水平等方面发挥重要作用[29]。Soo等[30]研究酶法提取的VCO对1,1-二苯基-2-三硝基苯肼(1,1-diphenyl-2-picrylhydrazyl,DPPH)和2,2-联氮-二(3-乙基-苯并噻唑-6-磺酸)二铵盐(2'-azinobis-(3-ethylbenzthiazoline-6-sulphonate),ABTS)两种自由基的清除能力来评价VCO的抗氧化活性,结果表明VCO样品的DPPH和ABTS自由基清除的半抑制浓度(50% inhibiting concentration,IC_{50})分别为47.87 μg/mL、142.56 μg/mL,与商品化的抗氧化剂二叔丁基对甲酚(Butylated Hydroxytoluene,BHT)的体外自由基清除能力相当(51.59 μg/mL、151.54 μg/mL)。Ghani等[6]通过测定DPPH自由基清除活性来比较通过不同提取工艺制备的VCO的体外抗氧化性高低,发现VCO样品的DPPH自由基清除的半抑制浓度(50% inhibiting concentration,IC_{50})在7.49~104.52 mg/mL范围内,发酵法制备的VCO的IC_{50}值(7.49 mg/mL)最小,远低于干榨法(104.52 mg/mL),这说明VCO的抗氧化活性的显著差异取决于工艺条件,前者的抗氧化活性最高。而对比分析不同制备工艺下的VCO的总酚含量(total phenolic content,TPC)发现,干榨法制备的VCO的TPC为1.56 mg GAE/g,远远低于发酵法制备的VCO的TPC(12.54 mg GAE/g),发酵过程有利于保存VCO中的酚类物质,从侧面也说明了TPC与抗氧化活性之间存在一定的相关性。一些临床药物会对非靶向组织产生许多副作用甚至严重的器官或组织毒性,越来越多的证据显示氧化应激作用与炎症反应与这些毒性密切相关,前者通过消耗机体中抗氧化酶,打破原本的氧化-还原平衡,炎症介质如白细胞介素-6(Interleukin,IL-6)、肿瘤坏死因子-α(tumor necrosis factor,TNF-α)和核因子-κB(nuclear factor,NF-κB)的表达可能参与其中。Famurewa等[31]研究了膳食补充VCO对服用抗癌药物甲氨蝶呤(methotrexate,MTX)所导致的大鼠肾毒性的缓解效应和抗氧化、抗炎症作用,结果发现MTX的诱导使得大鼠肾脏中氧化应激标记物超氧化物歧化酶(superoxide dismutase,SOD)、谷胱甘肽过氧化物酶(glutathion peroxidase,GSH-Px)和过氧化氢酶(catalase,CAT)活性显著降低,脂质过氧化产物丙二醛(malondialdehyde,MDA)在组织内大量积累,而在MTX致病前补充VCO可显著增强抗氧化酶活性,MDA含量明显减少,IL-6、一氧化氮(nitric oxide,NO)、C-反应蛋白(C-reactive protein,CRP)的表达水平明显降低,这说明VCO可通过改善机体抗氧化系统,增强抗氧化和抗炎症活性达到保护肾脏的功能。

3.2 抗菌和抗病毒作用

大量研究都报道了VCO对革兰氏阳性细菌(如

表3 不同提取方法制备的VCO的理化指标[17]

Table 3 Physical and chemical indexes of VCO prepared by different extraction methods

指标 Index	发酵法 Fermentation	酶法 Enzyme treatment	冻融法 Chilling and thawing	干榨法 Expression	精炼椰子油 Refined coconut oil	CAC限量 CAC limit
折光指数 Refractive index /25℃	1.45±0.04a	1.45±0.05a	1.45±0.04a	1.45±0.05a	1.45±0.02a	-
酸价 Acid value /(mg KOH/g)	0.40±0.00b	0.40±0.01b	0.38±0.02b	0.32±1.03a	0.34±0.04a	≤0.20
碘价 Iodine value /(g I_2/100 g)	6.05±0.03c	4.33±0.03b	7.13±0.01d	4.17±0.07a	5.70±0.05c	4.10-11.00
过氧化值 Peroxide value /(meq O_2/kg)	2.59±0.00b	2.34±0.00c	2.19±0.00e	1.47±0.00a	2.18±0.00d	≤3.00
皂化值 Saponification value /(mg KOH/g)	262.55±0.07c	259.55±0.12d	254.10±0.01e	264.04±0.02b	264.38±0.06a	250.00-260.00
水分含量 Moisture content /%	0.15±0.02c	0.15±0.05c	0.14±0.03b	0.12±0.02a	0.17±0.00d	-

注:含有完全不同小写字母的各组间有显著差异(P<0.05)

Note: Different lowercase letters indicate significant difference (P<0.05)

蜡样芽胞杆菌、金黄色葡萄球菌、单增李斯特菌和枯草芽孢杆菌等)、革兰氏阴性细菌(如大肠杆菌、沙门氏菌等)、脂质包覆病毒(如绵羊髓鞘脱落病毒、巨细胞病毒、流感病毒和丙型肝炎病毒等)以及真菌等微生物具有明显的抑制作用,而VCO中MCFA是其发挥抗菌活性的主要活性成分之一,尤其是月桂酸及其单甘酯[32-34]。一般而言,革兰氏阳性菌的细胞壁是由较厚的肽聚糖层组成,具有较强的极性,而革兰氏阴性菌的细胞壁主要成分是由脂质、多糖和蛋白质组成的脂多糖,疏水性较强,Loung等[35]研究发现月桂酸甘油酯具有两亲性,其结构中一端是疏水性的,另一端是亲水性的,无论是革兰氏阳性菌还是革兰氏阴性菌,它都可以破坏细菌的细胞壁,导致细胞膜裂解,抑制细菌的生长,进而保护宿主免受细菌侵染。月桂酸甘油酯是月桂酸的重要一种衍生物,对促进VCO抑制曲霉属(*Aspergillus* Sp.)、青霉属(*Penicillium* Sp.)、枝孢属(*Cladosporium* Sp.)和镰刀菌素(*Fusarium* Sp.)等微生物具有较大贡献[7]。Mukhtar等发现VCO可以作为一种新型抗真菌药物来控制口腔白念珠菌诱导的龋齿病,VCO会使白念珠菌细胞蛋白质构象发生改变,破坏菌体细胞膜的通透性,甚至使细胞膜发生破裂,胞质内容物释放,最终使细胞解体[36]。而除了VCO会破坏细胞膜这一抑菌机制,VCO中月桂酸及其单甘酯还会抑制菌丝的形成,阻碍菌体对宿主的入侵,降低致病性[37];其次它们还会降低在能量生产和营养转移方面发挥作用的酶的活性,干扰菌体正常生命活动来达到抗菌目的[38]。

VCO除了具有抗菌活性之外,其抗病毒活性也备受关注,尤其是对艾滋病病毒(human immunodeficiency virus,HIV)、新型冠状病毒(Novel SARS Coronavirus,SARS-CoV-2)等抗病毒活性日益受到关注。Widhiarta等[39]通过研究每日三餐摄入15 mL的VCO(为期6周)对年龄18~59岁的HIV阳性患者血液中$CD4^+$T淋巴细胞浓度的影响来确定VCO对HIV病毒增殖的抑制效应,结果发现在VCO干预6周后,摄入VCO的患者血液中$CD4^+$T淋巴细胞计数平均值为481±210.0 cell/μL,明显高于未摄入VCO的患者(343±129.1 cell/μL)。Angeles-Agdeppa等[40]研究了VCO对菲律宾63名成年疑似新冠病毒患者血液生化标志物C-反应蛋白(C-Reactive Protein,CRP)水平的影响,CRP水平通常会在出现疼痛或发烧等症状之前上升,并最终随着身体的恢复而下降,它是监测病毒感染的常用测试指标[41]。在VCO干预28天期间,分别在第0、14和28天测量CRP水平的变化,结果发现VCO干预组和对照组的平均CRP水平为7.4±2.3 mg/L、8.2±2.6 mg/L,均高于CRP的正常水平(≤5 mg/dL),可断定所有实验对象均有感染。在干预第14天,VCO干预组的CRP均值达到正常水平以下,之后一直趋于稳定,而对照组直到研究结束仍保持在初始水平,这说明VCO可作为新冠肺炎疑似病例的辅助补充药物。VCO的抗病毒机制主要有以下三点:1)诱导病毒包膜的裂解,VCO中月桂酸及其单甘酯会对病毒脂质胶囊层具有较强的破坏作用[39];2)抑制病毒成熟,月桂酸是最活跃的病毒增殖抑制剂,会干扰病毒复制循环和晚期成熟[42,43];3)阻止病毒蛋白与宿主细胞膜的结合[44]。

3.3 预防心血管疾病作用

流行病学研究表明大量饱和脂肪酸是诱导高脂血症和增加心血管疾病的风险因子,虽然VCO中含有超过90%的饱和脂肪酸,但富含MCFA的VCO对脂质代谢和心血管系统具有有益作用。VCO能够被肠道迅速吸收,不参与体内胆固醇的运输,能够显著降低机体中总胆固醇、甘油三酯和低密度脂蛋白组分的水平[45],对于患有慢性心血管疾病或婴幼儿来说是一种良好的能量来源[46]。大量研究发现,VCO对心血管系统具有保护作用,摄入VCO的实验动物血液中甘油三酯(triglyceride,TAG)、低密度脂蛋白胆固醇(low-density lipoprotein cholesterol,LDL-C)水平显著降低,高密度脂蛋白胆固醇(high-density lipoprotein cholesterol,HDL-C)水平升高,能够有效缓解血脂紊乱所造成的心血管并发症[47-49]。VCO中的多酚也是有助于降低心血管疾病发病概率的有效生物成分,Famurewa等[50]就证实了从VCO中分离的多酚可以预防重金属镉暴露所导致的血脂异常,显著提高HDL-C水平,使血清中总胆固醇(total cholesterol,TC)、TAG和LDL-C恢复至正常水平,VCO亦可能作为一种有益的膳食补充剂,改善脂质和胆固醇水平以及降低心血管疾病风险[51]。

VCO能够预防心血管疾病的相关机制主要有如下两种:1)摄入VCO会抑制肝脂酶、羟甲基戊二酰辅酶A(hydroxy methylglutaryl-CoA,HMG-CoA)还原酶、葡萄糖-6-磷酸脱氢酶和异柠檬酸脱氢酶的活性,酰基辅酶A羧化酶、脂肪酸合成酶及其固醇调节元件结合蛋白1(sterol regulatory element binding protein,SREBP-1)表达的减少会阻碍脂肪酸从头合成[52,53];2)VCO能够促进胆固醇逆向转运,存在

于VCO中的月桂酸通过过氧化物酶体增殖物激活受体α(peroxisome proliferator-activated receptor α, PPAR α)-肝脏X受体α(liver X receptor α, LXRα)信号通路上调B族I型清道夫受体(scavenger receptor b type I, SRB1)和三磷酸腺苷结合盒转运体A1(ATP binding cassette transporter A1, ABCA1)的表达,前者是位于肝细胞膜上的HDL受体,它既能介导肝脏对HDL-C的选择性摄取,又能促进外周组织细胞内游离胆固醇转运至HDL,从而维持胆固醇代谢的平衡并防止游离胆固醇在动脉壁中堆积[54]。后者作为一种细胞膜蛋白可与载脂受体结合,调节HDL的生物合成,增加其表达量可促进胞内胆固醇的流出,降低动脉粥样硬化风险[55]。

4 总结与展望

VCO作为一种功能性木本食用油,受到了公众和科学界的广泛关注,在食品、医药和日用品行业有着广阔的发展空间和市场前景。近年来越来越多的研究证实了由于MCFA(尤其是月桂酸)和酚类物质的存在,VCO对人体健康具有多种积极的作用,包括抗氧化、抗炎症、抗病毒、抗菌和预防心血管疾病等。在以饮食为基础的干预治疗或预防疾病原则的指导之下,VCO会作为膳食补充剂逐渐被保健食品和医药卫生领域广泛接纳。然而VCO的营养功效基本上是通过体外实验或动物模型展开研究的,临床和流行病学数据尚且不足,在未来应开展足够的临床研究,进一步探索VCO对疾病的预防、治疗和辅助作用及其分子机制,不断拓宽VCO的应用范围,提升其经济价值。

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