

初榨橄榄油中的微生物群及其对橄榄油品质的影响

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摘要:初榨橄榄油生产环境相对开放, 榨取橄榄油的原料、环境及设备中的微生物群都可能进入初榨橄榄油, 对油脂品质产生影响。为全面认识初榨橄榄油中微生物群以及从微生物层面控制初榨橄榄油品质, 从食品微生物学研究的视角, 综述了初榨橄榄油中酵母菌、细菌和霉菌等主要微生物群, 分析了油橄榄枝叶、果实和初榨橄榄油中的微生物群对油脂品质的影响, 介绍了采后储存的油橄榄果实及储存期的初榨橄榄油品质与微生物群之间的关系, 探讨了对有害微生物群影响初榨橄榄油品质的防控措施。研究认为酵母菌对初榨橄榄油储存期间的品质起主要的影响作用。通过避免采摘和储存过程中油橄榄果实的损伤, 保证加工过程中清洗用水和设备的洁净, 控制储存环境温度、光照和氧含量等措施, 可以有效防控有害微生物对橄榄油品质的负面影响。

关键词:初榨橄榄油; 微生物群; 橄榄油品质; 互作关系; 影响机制

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Microbiota in virgin olive oil and their effects on oil quality

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Abstract: The production environment of virgin olive oil (VOO) is relatively open, and the microbiota in the raw materials, environment and equipment of extracting olive oil may enter VOO, which may have effects on the quality of VOO. In order to fully understand the microbiota in VOO and control the quality of VOO at the microbial level, the main microbial species in VOO, including yeasts, bacteria and moulds were reviewed from the perspective of food microbiology research. The influence of microbiota in olive branches, leaves, fruits and VOO on the quality of VOO was analyzed. The relationship between the VOO microbiota and the quality of postharvest olive fruits and oil products during storage was introduced, and the measures to prevent harmful microbiota affecting VOO quality were discussed. Overall, yeasts play a major role in the quality of VOO during storage. The negative effects of harmful microbiota on the quality of VOO can be prevented and controlled by avoiding the damage of the olive fruit during pickings and storage, by ensuring the clean of the water used to wash the olive fruit and processing equipment, and by controlling external factors such as temperature, light and oxygen content of the storage environment.

Key words: virgin olive oil; microbiota; olive oil quality; interaction; effect mechanism

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初榨橄榄油是用新鲜的油橄榄果实不经加热和化学处理, 直接压榨而成, 未经任何精炼的油品。橄榄油被誉为“植物油皇后”, 一直以来都是油脂领域的研究热点之一。随着橄榄油微生物领域研究工作的不断深入, 现已证实初榨橄榄油生产过程中易受

各种微生物的污染,如清洗水、榨取分离和储存设备中出现的各种微生物。研究发现,初榨橄榄油中的微生物群主要由酵母菌、细菌和霉菌组成,它们可通过分泌多种酶类来影响橄榄油的理化特性和感官品质^[1]。初榨橄榄油中酵母菌、细菌及霉菌主要来源于油橄榄果实、枝叶及其不良储存环境^[2-3]。油橄榄果实的内部因素如pH、水分含量、油橄榄果皮的结构、抗菌化合物(酚类化合物和有机酸)及外部因素如环境温度、储存条件、包装类型、油橄榄品种和地域的差异都会影响初榨橄榄油中微生物的新陈代谢速率和类型,进而影响初榨橄榄油的品质^[4-5]。目前,国内有关油橄榄果实及初榨橄榄油微生物领域的研究较少。本文综述了初榨橄榄油中的微生物群及其对初榨橄榄油品质的影响,探讨了防控有害微生物群对初榨橄榄油品质影响的措施,以期国内有关初榨橄榄油中微生物领域的研究提供参考。

1 初榨橄榄油中的微生物群

1.1 酵母菌

初榨橄榄油中发现的酵母菌主要是在油橄榄果实破碎过程中随着固体颗粒和液相一起到新生产的初榨橄榄油中。在市售初榨橄榄油中发现了迪丹斯假丝酵母(*C. diddensiae*)和*N. wickerhamii*^[6-7];从Moraiolo和Frantoio品种的初榨橄榄油中发现了*N. molendinirolei*、*Y. terventina*和盔形毕赤酵母(*P. manshurica*)^[8];从新榨的Taggiasca品种初榨橄榄油中分离出了马克斯克鲁维酵母(*K. marxianus*)、喜橄榄假丝酵母(*C. oleophila*)、迪丹斯假丝酵母(*C. diddensiae*)、诺维吉假丝酵母(*C. norvegica*)、异常威克汉姆酵母(*W. anomalus*)和汉逊德巴利酵母(*D. hansenii*)^[9];从产自西班牙的橄榄油中分离出了*Groenewaldozyma auringiensis*和发酵拉钱斯氏酵母(*Lachancea fermentati*)^[10];同时还有研究者分离出了一些未知新种,如*C. adriatica*、*C. molendinirolei*、*O. kolombanensis*、*O. histrianica*和*Y. terventina*^[11-13]。从人类健康方面考虑,在商品初榨橄榄油中还发现了一些条件致病性酵母菌,如季也蒙迈耶氏酵母(*Meyerozyma guilliermondii*)和近平滑假丝酵母(*C. parapsilosis*)^[7,14]。Guerrini等^[15]对初榨橄榄油生产过程中出现频率较高的*N. wickerhamii*、*N. molendinirolei*、*Y. terventina*酵母菌进行了分离和研究。

Sheila等^[16]在油橄榄果实及其加工副产物中鉴定出7个属的酵母菌,分别为*Zygosaccharomyces*、*Pichia*、*Lachancea*、*Kluyveromyces*、*Saccharomyces*、*Candida*、*Torulasporea*。*C. adriatica*和*N. molendinirolei*是2种经常能从不同油橄榄栖息环境和橄榄油加工

副产物中分离得到的酵母菌^[17-19]。在初榨橄榄油加工过程的清洗水、破碎的油橄榄果实及压榨制取的橄榄油中均发现了*C. oleophila*、*C. diddensiae*、*C. norvegica*、*W. anomalus*和*D. hansenii*^[9]。因此,初榨橄榄油中发现的酵母菌主要来源于油橄榄果实和储存环境,在清洗、破碎油橄榄果实的过程中,酵母菌随油橄榄果实进入初榨橄榄油中。

1.2 细菌

油橄榄果实中的细菌组成与初榨橄榄油中的细菌组成密切相关。Santona等^[20]从特级初榨橄榄油中鉴定出沙雷氏菌属(*Serratia* spp.)和葡萄球菌属(*Staphylococcus* spp.)。Pizzolante等^[21]从保存1年的特级初榨橄榄油中鉴定出了3个科的6种细菌分离株,分别是肠杆菌科(OOWS-10, OOYS-10)、黄单胞菌科(OOOWS-2, OOOWS-9)、假单胞菌科(OOBS-2, OOYW-9),其中黄单胞菌科归属于嗜根寡养单胞菌,肠杆菌科与泛菌属高度同源。Fancello等^[22]对15种特级初榨橄榄油的细菌多样性分析发现,存在芽胞杆菌属(*Bacillus* spp.)、短芽孢杆菌属(*Brevibacillus* spp.)、微球菌属(*Micrococcus* spp.)、葡萄球菌属(*Staphylococcus* spp.)、泛菌属(*Pantoea* spp.)、考克氏菌属(*Kocuria* spp.)、赖氨酸芽胞杆菌属(*Lysinbacillus* spp.)、乳杆菌属(*Lactobacillus* spp.)。

Mina等^[23]在测定油橄榄枝叶中的细菌群落时发现,油橄榄叶和油橄榄枝中细菌的优势门是变形菌门、放线菌门和厚壁菌门。Pascasio等^[2]检测发现油橄榄果皮中的细菌属于变形菌门、放线菌门和厚壁菌门,其中变形菌门包括拉恩氏菌属、克吕沃尔氏菌属、*Serratia* spp.、*Pantoea* spp.、*Averyella*、哈夫尼菌属、甲基杆菌属,放线菌门包括短小杆菌属、*Fronidhabitans*、厚壁菌门包括肠球菌属。此外,在油橄榄果实中还发现了*Serratia* spp.^[20]。比较油橄榄枝叶、果实和初榨橄榄油中分离出来的微生物群,可以发现都含有变形菌门,因而可以初步判定初榨橄榄油中检出的细菌主要来源于油橄榄果实和枝叶。

1.3 霉菌

研究表明,用健康果实榨取的初榨橄榄油中霉菌数量很少,这是因为生产过程中过滤处理能减少初榨橄榄油中的霉菌数量,并且极性酚类物质的抗菌作用会抑制初榨橄榄油中霉菌的生长^[24-25]。Ciardini等^[25]在初榨橄榄油中检测到曲霉属(*Aspergillus*)。Al-Ameiri等^[26]从油橄榄果蝇侵害的油橄榄果实中确定了3个霉菌属,即*Aspergillus*、青霉属(*Penicillium*)和镰孢属(*Fusarium*),分离出了7种霉菌,分别为茄

链格孢菌 (*Alternaria solani*)、黑曲霉 (*Aspergillus niger*)、草本枝孢 (*Cladosporium herbarum*)、腐皮镰孢菌 (*Fusarium solani*)、指状青霉 (*Penicillium digitatum*)、意大利青霉 (*P. italicum*)和匍枝根霉 (*Rhizopus stolonifer*),这7种霉菌能够在初榨橄榄油中生长和繁殖。通过比较可知,初榨橄榄油、储藏油橄榄果实和油橄榄果蝇产卵地中都含有 *Aspergillus*,由此推测初榨橄榄油中霉菌主要来自油橄榄果实的虫害和不良储存环境。

2 初榨橄榄油中的微生物群对橄榄油品质的影响

2.1 采后储存过程中微生物群对油橄榄果实及油品品质的影响

油橄榄果实的采收时间很短,由于榨油厂规模小,果实成熟期间,常有大量油橄榄果堆积起来等待加工,随着储存时间的延长或存放油橄榄果的袋子内温度和湿度的升高,果实中酵母菌、细菌和霉菌的活性会增强,从而加速油橄榄果腐烂,并导致初榨橄榄油品质劣变,严重影响初榨橄榄油的品质^[27-28]。Zullo等^[29]研究发现,油橄榄果实在储存的前4 d,酵母菌、细菌和霉菌数量迅速增加,而酵母菌、细菌和霉菌产生的氧化还原酶使油橄榄果实在储存过程中总酚含量减少,最终导致初榨橄榄油中总酚含量降低。Vichi等^[30]研究发现,油橄榄果实在密封塑料袋中或打开的箱子中储存21 d,乳酸菌、醋酸菌、肠道细菌、霉菌和假单胞菌的增殖速度很快,这些微生物群促进了油橄榄果实中挥发性酚类物质(食品腐败产物)的产生,最终提高了初榨橄榄油中挥发性酚类物质的浓度。Vichi等^[31]研究发现,从被微生物群污染的油橄榄果实中榨取的油品品质较差,而且微生物群对橄榄油品质的影响大于其他因素(如杀菌时间和温度)。上述研究表明,微生物群活动会影响采后储存的油橄榄果实品质,进而影响油品质量。因此,为提高橄榄油的品质,在油橄榄果采收前后进行有效管理是避免橄榄油受到微生物群污染的重要措施。

2.2 微生物群对初榨橄榄油在储存期间品质的影响

在初榨橄榄油中,酵母菌、细菌和霉菌均可被检出,然而由于极性酚类物质(130~170 mg/kg)的作用,细菌和霉菌的生长受到抑制,存活不超过6个月,而酵母菌的数量和所产酶活性虽然降低,但在6个月和12个月仍被检出^[24]。由此可见,酵母菌对初榨橄榄油储存期间的品质起着主要的影响作用。一些酵母菌有助于改善初榨橄榄油在储存期间的理

化性质和感官特性^[16,32],如:酿酒酵母(*Saccharomyces cerevisiae*)和 *C. wickerhamii* 产生的 β -葡萄糖苷酶能水解橄榄油中的苦味化合物,从而减少储存期间橄榄油的苦味^[33]。而另一些酵母菌会使储存的橄榄油出现感官缺陷,如:*Saccharomyces cerevisiae* 1525和 *Williopsis californica* 1639所产的脂肪酶能催化甘油三酯水解,增加储存过程中橄榄油的酸值,降低油品品质^[19,32]。Zullo等^[34]将 *C. adriatica* DAPES 1933、*C. wickerhamii* DAPES 1885和 *C. diddensiae* DAPES 1912等不同的菌株接种到初榨橄榄油中,发现储存4个月后这些菌株会产生异味物质破坏初榨橄榄油的风味。另外,橄榄油在储存过程中,微生物群的存活率和酶活性也直接影响橄榄油中酚类化合物的含量和含水量,进而影响油脂的营养价值^[35]。上述研究结果表明,存在于油橄榄果实和初榨橄榄油中的酵母菌对油品品质有不同程度的影响。

2.3 对有害微生物群影响初榨橄榄油品质的防控措施

初榨橄榄油中存在的微生物群主要是由油橄榄果实引入,但目前针对种植、采摘、储存和加工过程中,预防有害微生物群引入橄榄油的研究较少。Fakas等^[28]研究表明,在果实采收和储存期间的损伤以及采后不合理的堆积会改变油橄榄果实中的酵母菌、细菌和霉菌组成,致使橄榄油中的微生物群发生变化,最终影响初榨橄榄油的感官特性和理化品质。因此,可通过减少油橄榄果实损伤及尽快加工处理果实来减少微生物群引入初榨橄榄油。Andres等^[36]研究发现,在5℃和10℃下4种初榨橄榄油可以储存3年,在20℃下Arbequina和Hojiblanca品种初榨橄榄油可以储存2年,而Picual和Cornicabra品种初榨橄榄油可以储存3年。这表明,低温可以在一定程度上抑制初榨橄榄油中微生物群的生长繁殖。此外,还可以通过控制氧气浓度、光照强度和包装材料等外部因素来防控有害微生物群对初榨橄榄油品质的负面影响^[37-39]。Zullo等^[40]研究了橄榄油加工过程中棉花过滤器和纤维素过滤器对2种初榨橄榄油中微生物群组成的影响,结果表明,这2种过滤系统都能有效减少油中酵母菌、细菌和霉菌的数量,其中纤维素过滤器的效果更显著。

综上所述,通过在采摘和储存过程中避免损伤油橄榄果实,采摘后及时进行加工处理,保证油橄榄果实清洗用水和生产加工设备的洁净,控制储存环境温度、光照和氧含量等措施,可有效防控有害微生物群对初榨橄榄油品质的负面影响。

3 结语

综合分析已有的研究报道发现,目前有关初榨橄榄油中的微生物群研究还存在以下3个问题:

(1)初榨橄榄油对于微生物的生长而言是个高油脂、低氧(或无氧)的特殊生长环境,不利于微生物生存,只有极少数微生物可以利用初榨橄榄油的脂肪酸作为碳源,在含有抑菌橄榄多酚的初榨橄榄油中存活。目前有关初榨橄榄油中微生物多样性的研究主要是基于可培养技术的分离鉴定和分析,而不能反映未培养微生物的多样性。因此,在现有研究基础之上,结合新型未培养微生物分离分析技术,可较为准确和全面地揭示初榨橄榄油中微生物多样性的真实面貌。

(2)目前对初榨橄榄油中分离培养的主要微生物群的生物学特性研究和分析还十分缺乏,未完全阐明在初榨橄榄油储存期间微生物对其风味和感官品质的影响以及如何防控有害微生物群对橄榄油品质的负面影响。因此,有必要采用微生物学、色谱学、代谢组学和食品风味化学等多学科交叉技术手段研究初榨橄榄油中存在的微生物活性及其与储存期内油品品质变化之间的互作关系。

(3)油橄榄作为舶来树种,引种栽培于我国川、甘、陕、滇等省份,其生长环境的气候因子和土壤特性都发生了很大变化,势必会导致油橄榄微生物多样性的改变,进而会影响初榨橄榄油微生物群的变化。目前国内对此方面的研究和认识较为空缺。

从长远发展国产橄榄油产业和地方特色支柱产业的角度考虑,有必要开展上述3方面的基础性、系统性研究工作。

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