

非药物改变肠道微生物群以预防糖尿病肾病的研究进展

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摘 要

本综述旨在介绍对糖尿病肾病(diabetic kidney disease, DKD)患者肠道微生物群产生积极影响的干预措施。针对肠道菌群的干预措施(包括益生菌和饮食调整)在调节肠道菌群方面有一定的潜力。饮食调整中部分天然食品如多酚类和花青素可通过调节肠道菌群的组成来帮助清除尿毒症患者体内的毒素,从而延缓糖尿病肾病进展。也有动物模型研究表明粪便微生物移植(FMT)对调节菌群失调及改善慢性肾脏疾病具有积极作用,涉及DKD患者的研究仍显不足,需要进一步研究,未来可能是一个延缓DKD进展的新思路。益生菌中的乳酸杆菌和双歧杆菌可能有助于降低尿素和肌酐水平,尿毒症期患者的研究欠缺。高纤维饮食以及姜黄素等补充剂可通过调节肠道微生物群和减少氧化应激来降低毒素。

关键词

肠道微生物, 超级食物, DKD

Research Progress on Non-Pharmacological Modification of Gut Microbiota for Preventing Diabetic Kidney Disease

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Abstract

This review aims to introduce interventions that have positive effects on the gut microbiota in patients with diabetic kidney disease (DKD). Interventions targeting the gut microbiota, including probiotics and dietary adjustments, have shown potential in regulating gut microbiota. Certain natural foods in dietary adjustments, such as polyphenols and anthocyanins, can help remove toxins from the bodies of uremic patients by regulating gut microbiota composition, thereby slowing the progression of DKD. Animal model studies have also shown that fecal microbiota transplantation (FMT) has positive effects on regulating dysbiosis and improving chronic kidney disease, but research involving DKD patients is still insufficient and requires further study. This may be a new approach to slowing DKD progression in the future. Lactobacillus and Bifidobacterium in probiotics may help reduce urea and creatinine levels, but research on uremic patients is lacking. High-fiber diets and supplements such as curcumin can reduce toxins by regulating gut microbiota and reducing oxidative stress.

Keywords

Gut Microbiota, Superfood, DKD

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1. 引言

慢性肾脏病(CKD)影响着全球超过 10%的成年人[1]。已知的 CKD 病因多达数十种,糖尿病是其主要诱因,糖尿病也是引起终末期肾病(ESKD)的主要原因之一,由糖尿病引发终末期肾病患者的比例持续攀升,这种需要肾脏替代治疗的疾病已成为国家医疗体系的重大负担[2]。DKD 不仅致死率高,更对全球公共卫生构成严峻挑战,亟需制定新策略来预防 DKD,延缓糖尿病引起的慢性肾脏病进展[3]。近年来,人们日益关注肠-肾轴在 DKD 发生与发展中的作用。

2. 肠道微生物

肠肾轴指肠道微生态系统与肾脏之间的双向调节机制。肠道菌群失调是指由饮食、药物使用、免疫系统活动及肠道黏膜状态改变引发的肠道微生物群自然变化。CKD 患者体内尿素潴留,尿素渗入肠腔,从而促进尿素分解菌的增殖,这一过程会加重肠道微生物失衡;此外,氧化应激、噬菌体激活以及细菌素生成等压力因素也会进一步强化这些变化,最终,微生物多样性降低,致病菌群开始占据主导地位[4]。肠道菌群的组成和多样性受多种内源性和外源性因素共同影响,其中饮食因素起着关键作用。例如,高纤维的地中海饮食与富含饱和脂肪酸和单糖的西方饮食相比,在机体的肠道内会形成不同的微生物群落。此外,随着年龄增长,肠道菌群也会因自然老化过程发生变化,这种变化通常伴随着微生物群的多样性下降、菌群失调易感性的增加[5]。肠道内乳酸菌(如乳杆菌)和双歧杆菌数量减少, γ -变形菌纲、 β -变形菌纲及肠杆菌科菌群数量增加。由于肠-肝轴(指肠道与肝脏之间通过门静脉、胆道系统和循环系统来实现“双向交流”的一种途径)的存在,大肠杆菌、沙门氏菌、志贺氏菌和耶尔森菌等病原体不仅能在肠道引发炎症反应,还能影响其他器官。通过门静脉系统,肝脏会暴露于脂多糖(LPS)等细菌内毒素中,这些毒

素会激活免疫细胞,尤其是库普弗细胞,促使产生白细胞介素(IL-1 β 、IL-6、IL-8)、肿瘤坏死因子 α (TNF- α)等促炎性细胞因子,进而引发全身性炎症反应。这种慢性低度炎症可能在糖尿病和肾病的发展过程中起到重要作用[6]。

3. 超级食物

有学者研究表明,在2型糖尿病和慢性肾脏病(CKD)患者的饮食中添加所谓“超级食物”(指富含某些营养素或者植物化合物,比同类食物含有更丰富的营养,更有益于身体健康)具有潜在健康益处[7]。浆果、奇亚籽、亚麻籽、绿茶、西兰花、姜黄和大蒜等食物富含多酚、类黄酮、Omega-3 多不饱和脂肪酸、膳食纤维及抗氧化剂等生物活性成分,这些成分具有抗炎、抗氧化和调节葡萄糖代谢的特性。对于CKD患者而言,某些超级食物可减轻氧化应激、改善血脂水平并维持肠道菌群平衡,有助于延缓疾病进展并提升整体代谢健康。但需注意的是,由于电解质失衡(如高钾血症)需要饮食限制,因此应由临床营养师指导个体化选择合适食物。尽管研究结果令人鼓舞,但仍需通过更多随机对照临床试验来验证长期使用“超级食物”对这类患者群体的安全性和有效性[8]。

多酚可分为水解单宁(酸酯类多酚)和缩合单宁(黄烷醇类多酚或原花色素),后者包括黄酮类和木脂素类等,其中黄酮类是多酚化合物中规模最大、最广为人知的类别,这类物质具有抗炎抗氧化特性,既能发挥护肾功效,又能改善肠道菌群失调[9]。多酚在肠道中的吸收率通常较低,它在肠道微生物群发生水解作用并被吸收,进而转化为另一种形式的化合物,能够有效保护肠道细胞,促进特定菌群生长[10]。

富含生物活性成分的食物,如姜黄、浆果、蔓越莓、巧克力、蜂胶、甜菜、西兰花、大蒜、肉桂、咖啡及巴西坚果,不仅能调节肠道菌群结构,还能调控炎症相关的转录因子,减轻氧化应激反应,同时保护肾功能[11]-[13]。研究证实,大蒜(学名: *Allium sativum* L.)能够显著提升肠道菌群多样性,并改善乳酸杆菌属、双歧杆菌和普雷沃氏菌等菌群的低水平状态[14]。肠道微生物通过多酚类物质产生的代谢产物,能为肠道屏障和免疫系统带来多重益处,显著增强机体抗氧化能力,此外,经过肠道微生物作用的植物化学物质在调控菌群定植方面也发挥着重要作用[15][16]。

花青素广泛存在于花卉、果实、叶片、茎秆中,偶尔也会出现在根部和木质部。水果蔬菜中的花青素能够调节肠道菌群组成,促进双歧杆菌属、乳酸杆菌属和肠球菌属的增殖,同时增加短链脂肪酸的生成量,从而增强肠道屏障功能来调节免疫系统[17]。研究表明,食用蓝莓、覆盆子、蔓越莓和草莓可作为调节肠道菌群、逆转慢性肾脏病菌群失调的治疗策略[18]。

富含纤维的浆果通过影响产黏液的细菌和产短链脂肪酸菌的数量,增加肠道菌群多样性[19]。此外,这些水果通过增强肠道紧密连接蛋白(如闭合蛋白、紧密连接蛋白1 TJP1 及粘蛋白)相关 mRNA 的表达,进一步加强肠道屏障;它们也能有效减少尿毒症毒素和脂多糖向血液中的转移,从而延缓慢性肾病患者的病情进展[20]。

甜菜根含有许多生物活性的植物化学物质,包括甜菜碱(如甜菜花青素和甜菜黄酮)、类黄酮、多酚、皂苷以及无机硝酸盐(硝酸盐);它也是钾、钠、磷、钙、镁、铜、铁、锌和锰等多种矿物质的丰富来源[21]。甜菜根中的成分可增加肠道微生物群的多样性并促进短链脂肪酸的生成[22]。研究表明,使用含姜黄素的补充剂(400~1500 mg/天)可显著降低血液透析患者的血清 hs-CRP 和 IL-6 水平[23]。

姜黄素是一种由姜黄产生的亮黄色化学物质,已被世界卫生组织、欧洲议会和美国食品药品监督管理局批准为食品添加剂。姜黄可以改变肠道微生物群的组成,改善肠道屏障渗透性,并增加肠道碱性磷酸酶的催化活性。也有研究表明血液透析患者使用含姜黄素的补充剂(400~1500 mg/天),患者血清 hs-CRP 和 IL-6 水平的显著降低[24]。蜂胶,或称“蜜蜂胶”,是由蜜蜂通过混合唾液、蜂蜡和从植物采集的花粉制成的树脂状混合物。在 250 mg/天的剂量下,蜂胶具有显著的抗炎特性,可降低细胞因子水平[25]。

4. 粪菌移植

尿素和氨水平升高以及 pH 值上升会促进胃肠道中好氧细菌(如大肠杆菌)的生长,同时降低厌氧细菌(如双歧杆菌和乳酸菌)的水平。摄入双歧杆菌可以通过限制好氧细菌的增殖来恢复胃肠道中细菌的适当平衡[26][27]。研究表明,给予这些益生菌后人体血尿素氮水平显著降低[28]。摄入植物乳杆菌后可导致慢性肾脏疾病患者体内的胱抑素(肾功能的生物标志物)的水平明显下降,从而保护肾功能[29]。补充益生菌可通过延缓肌酐、胱抑素 C 和血尿素氮水平的升高、降低尿白蛋白/肌酐来改善肾功能,当干预周期超过 8 周或益生菌剂量低于 40 亿 CFU/天时,肌酐降低幅度更大,而当益生菌补充剂量超过 40 亿 CFU/天时,血尿素氮的降幅更为显著[30]。乳酸杆菌和双歧杆菌等益生菌对糖尿病肾病患者具有积极作用[31]。尽管目前仍需大量研究和深入分析来验证益生菌改善肾功能的效果,但这一疗法似乎是一种安全的干预手段,未来可能在延缓糖尿病肾病进展方面带来益处。

肾脏疾病中的菌群失调对患者体内尿毒症毒素的积累有显著危害。目前关于粪菌移植(FMT)对糖尿病肾病影响的研究相对较少。不过已有研究表明,该技术对其他病因引发的慢性肾脏疾病具有显著疗效。周等学者曾报道一例膜性肾病合并慢性腹泻患者接受健康供体粪便移植的病例,该患者在间隔 28 天接受了两次粪菌移植手术,术后肾功能指标明显改善,表现为肌酐和尿素水平下降,血清白蛋白水平升高[32]。慢性肾脏病动物模型研究显示,在粪菌移植后,尿素氮水平有所降低[33]。血液透析(HD)患者通常被建议限制钾摄入量,可能导致水果蔬菜摄入减少和膳食纤维摄入下降,慢性肾脏病患者的肠道常伴有便秘症状,这也是导致菌群失调和毒素吸收增加的另一因素。我们可以推测,通过调整糖尿病患者的肠道菌群结构,将有助于改善其糖尿病肾病症状,通过粪便微生物移植(FMT)技术调节肠道菌群,有望为这类患者带来潜在的健康益处。

5. 总结

一些天然食物成分,如多酚、姜黄素和花青素,能够调节肠道微生物群的组成,增加尿毒症毒素的排泄,从而减缓糖尿病肾病的进展。膳食纤维摄入量较高可降低糖尿病肾病的风险。粪便微生物移植(FMT)已被证明对调节动物模型中的菌群失调和对延缓慢性肾脏病的进展有积极影响,我们可以通过观察粪便微生物移植对糖尿病肾病治疗的长期影响,为这种干预手段的有效性提供证据。

6. 局限性和未来展望

目前关于肠道菌群与 DKD 关联的机制研究仍处于初步阶段,许多假说缺乏直接证据支持;肠道菌群失调如何具体导致肾脏损伤的分子通路尚未完全阐明;肠道微生物组成存在显著的个体间差异,这使得干预措施的标准化和效果评估变得复杂;年龄、饮食、遗传背景等因素都会影响干预效果;现有研究多为短期观察,缺乏长期随访数据证明饮食或益生菌干预对 DKD 预防的持久性效果;动物模型与人类疾病存在差异,许多在动物实验中显示有效的方法在人体试验中效果有限或不可重复。

未来研究方向可以向着干预精准微生物组考虑:开发基于个体微生物组特征的个性化干预策略,结合机器学习预测不同患者对特定干预措施的可能反应;结合宏基因组学、代谢组学和蛋白质组学技术,全面解析菌群-宿主互作网络,识别关键功能菌株和代谢物;探索噬菌体疗法、菌群移植(FMT)和工程菌等新型干预方式,提高靶向性和安全性;建立统一的微生物组分析标准和 DKD 生物标志物体系,便于不同研究间的比较和整合;促进微生物学、肾脏病学、营养学和数据科学的深度合作,解决这一复杂医学问题的多方面挑战。未来研究应着重于从相关性研究转向因果性探索,并通过设计严谨的随机对照试验验证各种非药物干预的实际临床价值。

参考文献

- [1] Jager, K.J., Kovesdy, C., Langham, R., Rosenberg, M., Jha, V. and Zoccali, C. (2019) A Single Number for Advocacy and Communication—Worldwide More than 850 Million Individuals Have Kidney Diseases. *Kidney International*, **96**, 1048-1050. <https://doi.org/10.1016/j.kint.2019.07.012>
- [2] Koye, D.N., Shaw, J.E., Reid, C.M., Atkins, R.C., Reutens, A.T. and Magliano, D.J. (2017) Incidence of Chronic Kidney Disease among People with Diabetes: A Systematic Review of Observational Studies. *Diabetic Medicine*, **34**, 887-901. <https://doi.org/10.1111/dme.13324>
- [3] Perkovic, V., Tuttle, K.R., Rossing, P., Mahaffey, K.W., Mann, J.F.E., Bakris, G., *et al.* (2024) Effects of Semaglutide on Chronic Kidney Disease in Patients with Type 2 Diabetes. *New England Journal of Medicine*, **391**, 109-121. <https://doi.org/10.1056/nejmoa2403347>
- [4] Weiss, G.A. and Hennek, T. (2017) Mechanisms and Consequences of Intestinal Dysbiosis. *Cellular and Molecular Life Sciences*, **74**, 2959-2977. <https://doi.org/10.1007/s00018-017-2509-x>
- [5] Wang, Y., Zhao, J., Qin, Y., Yu, Z., Zhang, Y., Ning, X., *et al.* (2022) The Specific Alteration of Gut Microbiota in Diabetic Kidney Diseases—A Systematic Review and Meta-Analysis. *Frontiers in Immunology*, **13**, Article ID: 908219. <https://doi.org/10.3389/fimmu.2022.908219>
- [6] 王媛媛, 周华. 慢性肾脏病微炎症与肠道菌群的研究进展[J]. 中国实用内科杂志, 2022, 42(5): 423-426.
- [7] Trandafir, M., Pircalabioru, G. and Savu, O. (2024) Microbiota Analysis in Individuals with Type Two Diabetes Mellitus and End-Stage Renal Disease: A Pilot Study. *Experimental and Therapeutic Medicine*, **27**, Article No. 211. <https://doi.org/10.3892/etm.2024.12500>
- [8] Mafra, D., Borges, N., Alvarenga, L., Esgalhado, M., Cardozo, L., Lindholm, B., *et al.* (2019) Dietary Components That May Influence the Disturbed Gut Microbiota in Chronic Kidney Disease. *Nutrients*, **11**, Article No. 496. <https://doi.org/10.3390/nu11030496>
- [9] Zheng, X., Huang, Y., Yang, M., Jin, L., Zhang, X., Zhang, R., *et al.* (2024) Vitamin D Is Involved in the Effects of the Intestinal Flora and Its Related Metabolite TMAO on Perirenal Fat and Kidneys in Mice with DKD. *Nutrition & Diabetes*, **14**, Article No. 42. <https://doi.org/10.1038/s41387-024-00297-z>
- [10] Zaky, A., Glastras, S.J., Wong, M.Y.W., Pollock, C.A. and Saad, S. (2021) The Role of the Gut Microbiome in Diabetes and Obesity-Related Kidney Disease. *International Journal of Molecular Sciences*, **22**, Article No. 9641. <https://doi.org/10.3390/ijms22179641>
- [11] Cai, K., Ma, Y., Cai, F., Huang, X., Xiao, L., Zhong, C., *et al.* (2022) Changes of Gut Microbiota in Diabetic Nephropathy and Its Effect on the Progression of Kidney Injury. *Endocrine*, **76**, 294-303. <https://doi.org/10.1007/s12020-022-03002-1>
- [12] Wang, X., Ma, Y., Xu, Q., Shikov, A.N., Pozharitskaya, O.N., Flisyuk, E.V., *et al.* (2023) Flavonoids and Saponins: What Have We Got or Missed? *Phytomedicine*, **109**, Article ID: 154580. <https://doi.org/10.1016/j.phymed.2022.154580>
- [13] Mafra, D., Kalantar-Zadeh, K. and Moore, L.W. (2021) New Tricks for Old Friends: Treating Gut Microbiota of Patients with CKD. *Journal of Renal Nutrition*, **31**, 433-437. <https://doi.org/10.1053/j.jrn.2021.07.002>
- [14] Mafra, D., Borges, N.A., Lindholm, B., Shiels, P.G., Evenepoel, P. and Stenvinkel, P. (2020) Food as Medicine: Targeting the Uraemic Phenotype in Chronic Kidney Disease. *Nature Reviews Nephrology*, **17**, 153-171. <https://doi.org/10.1038/s41581-020-00345-8>
- [15] Koppe, L., Fouque, D. and Soulage, C.O. (2018) The Role of Gut Microbiota and Diet on Uremic Retention Solutes Production in the Context of Chronic Kidney Disease. *Toxins*, **10**, Article No. 155. <https://doi.org/10.3390/toxins10040155>
- [16] Ribeiro, M., Alvarenga, L., Cardozo, L.F.M.F., Chermut, T.R., Sequeira, J., de Souza Gouveia Moreira, L., *et al.* (2021) From the Distinctive Smell to Therapeutic Effects: Garlic for Cardiovascular, Hepatic, Gut, Diabetes and Chronic Kidney Disease. *Clinical Nutrition*, **40**, 4807-4819. <https://doi.org/10.1016/j.clnu.2021.03.005>
- [17] Kwon, C., Ediriweera, M.K. and Kim Cho, S. (2023) Interplay between Phytochemicals and the Colonic Microbiota. *Nutrients*, **15**, Article No. 1989. <https://doi.org/10.3390/nu15081989>
- [18] Mithul Aravind, S., Wichienchot, S., Tsao, R., Ramakrishnan, S. and Chakkaravarthi, S. (2021) Role of Dietary Polyphenols on Gut Microbiota, Their Metabolites and Health Benefits. *Food Research International*, **142**, Article ID: 110189. <https://doi.org/10.1016/j.foodres.2021.110189>
- [19] Verediano, T.A., Stampini Duarte Martino, H., Dias Paes, M.C. and Tako, E. (2021) Effects of Anthocyanin on Intestinal Health: A Systematic Review. *Nutrients*, **13**, Article No. 1331. <https://doi.org/10.3390/nu13041331>
- [20] Coutinho-Wolino, K.S., Melo, M.F.S., Mota, J.C., Mafra, D., Guimarães, J.T. and Stockler-Pinto, M.B. (2023) Blueberry, Cranberry, Raspberry, and Strawberry as Modulators of the Gut Microbiota: Target for Treatment of Gut Dysbiosis in

- Chronic Kidney Disease? from Current Evidence to Future Possibilities. *Nutrition Reviews*, **82**, 248-261. <https://doi.org/10.1093/nutrit/nuad048>
- [21] Arabi, S.M., Bahari, H., Hamidipor, S., Bahrami, L.S., Feizy, Z., Nematy, M., *et al.* (2022) The Effects of Curcumin-containing Supplements on Inflammatory Biomarkers in Hemodialysis Patients: A Systematic Review and Meta-Analysis. *Phytotherapy Research*, **36**, 4361-4370. <https://doi.org/10.1002/ptr.7642>
- [22] Mirmiran, P., Houshialsadat, Z., Gaeini, Z., Bahadoran, Z. and Azizi, F. (2020) Functional Properties of Beetroot (*Beta vulgaris*) in Management of Cardio-Metabolic Diseases. *Nutrition & Metabolism*, **17**, Article No. 3. <https://doi.org/10.1186/s12986-019-0421-0>
- [23] Moreira, L.d.S.G., Fanton, S., Cardozo, L., Borges, N.A., Combet, E., Shiels, P.G., *et al.* (2021) Pink Pressure: Beetroot (*Beta vulgaris rubra*) as a Possible Novel Medical Therapy for Chronic Kidney Disease. *Nutrition Reviews*, **80**, 1041-1061. <https://doi.org/10.1093/nutrit/nuab074>
- [24] Pivari, F., Mingione, A., Piazzini, G., Ceccarani, C., Ottaviano, E., Brasacchio, C., *et al.* (2022) Curcumin Supplementation (Meriva®) Modulates Inflammation, Lipid Peroxidation and Gut Microbiota Composition in Chronic Kidney Disease. *Nutrients*, **14**, Article No. 231. <https://doi.org/10.3390/nu14010231>
- [25] Anvarifard, P., Ostadrahimi, A., Ardalan, M., Anbari, M. and Ghoreishi, Z. (2023) The Effects of Propolis on Pro-Oxidant-Antioxidant Balance, Glycemic Control, and Quality of Life in Chronic Kidney Disease: A Randomized, Double-Blind, Placebo-Controlled Trial. *Scientific Reports*, **13**, Article No. 9884. <https://doi.org/10.1038/s41598-023-37033-z>
- [26] Hida, M., Aiba, Y., Sawamura, S., Suzuki, N., Satoh, T. and Koga, Y. (1996) Inhibition of the Accumulation of Uremic Toxins in the Blood and Their Precursors in the Feces after Oral Administration of Lebenin®, a Lactic Acid Bacteria Preparation, to Uremic Patients Undergoing Hemodialysis. *Nephron*, **74**, 349-355. <https://doi.org/10.1159/000189334>
- [27] Taki, K., Takayama, F. and Niwa, T. (2005) Beneficial Effects of Bifidobacteria in a Gastroresistant Seamless Capsule on Hyperhomocysteinemia in Hemodialysis Patients. *Journal of Renal Nutrition*, **15**, 77-80. <https://doi.org/10.1053/j.jrn.2004.09.028>
- [28] Fagundes, R.A.B., Soder, T.F., Grokoski, K.C., Benetti, F. and Mendes, R.H. (2018) Probiotics in the Treatment of Chronic Kidney Disease: A Systematic Review. *Brazilian Journal of Nephrology*, **40**, 278-286. <https://doi.org/10.1590/2175-8239-jbn-3931>
- [29] Miraghajani, M., Zaghian, N., dehkohneh, A., Mirlohi, M. and Ghiasvand, R. (2017) Probiotic Soy Milk Consumption and Renal Function among Type 2 Diabetic Patients with Nephropathy: A Randomized Controlled Clinical Trial. *Probiotics and Antimicrobial Proteins*, **11**, 124-132. <https://doi.org/10.1007/s12602-017-9325-3>
- [30] Dai, Y., Quan, J., Xiong, L., Luo, Y. and Yi, B. (2022) Probiotics Improve Renal Function, Glucose, Lipids, Inflammation and Oxidative Stress in Diabetic Kidney Disease: A Systematic Review and Meta-Analysis. *Renal Failure*, **44**, 862-880. <https://doi.org/10.1080/0886022x.2022.2079522>
- [31] Vlachou, E., Ntikoudi, A., Govina, O., Lavdaniti, M., Kotsalas, N., Tsartsalis, A., *et al.* (2020) Effects of Probiotics on Diabetic Nephropathy: A Systematic Review. *Current Clinical Pharmacology*, **15**, 234-242. <https://doi.org/10.2174/1574884715666200303112753>
- [32] Zhou, G., Zeng, J., Peng, L., Wang, L., Zheng, W., Wu, D., *et al.* (2021) Fecal Microbiota Transplantation for Membranous Nephropathy. *CEN Case Reports*, **10**, 261-264. <https://doi.org/10.1007/s13730-020-00560-z>
- [33] Barba, C., Soulage, C.O., Caggiano, G., Glorieux, G., Fouque, D. and Koppe, L. (2020) Effects of Fecal Microbiota Transplantation on Composition in Mice with CKD. *Toxins*, **12**, Article No. 741. <https://doi.org/10.3390/toxins12120741>