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Sağlık ve Hastalıklara Etkisi

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İçindekiler

Bağırsak Mikrobiyomu ve Mikrobiyomun Sağlık ve Hastalıklara Etkisi İnsan ve Hayvanın Mikrobiyal Dünyaya ve Ekolojik Dengeye Katkısı

Zajeba Tabashsum, Zabdiel Alvarado-Martinez, Ashely Houser, Joselyn Padilla, Nishi Shah, and Alana Young

1. Giriş

300 yıldan daha uzun bir süre önce Antonie van Leeuwenhoek, insan plaklarında morfolojik olarak çeşitli mikropları gözlemlemiştir ve bu çevrede olduğu kadar hayvan ve insan vücudunda da var olan karmaşık bir mikrobiyotanın keşfedilmesine yol açmıştır (Lane2015). Böylece, mikropların bu dünyanın bir parçası olduğunun anlaşılması başlamıştır ve o zamandan beri mikropların yaşamın her alanında önemli roller oynadığı fikri daha belirgin hale gelmiştir. Mikrobiyom, sistemde bulunan tüm mikropların toplamı olan faydalı, nötr ve zararlı mikropların toplamıdır. Çeşitli mikroplar; insanlar, bitkiler, hayvanlar, toprak, su kütleleri ve atmosfer gibi farklı ortamların bir parçası olarak bulunabilirler, bu da bir konağın mikrobiyomunun sağlığını ve dengesini şekillendirmenin ve korumanın son derece önemli olduğunu kanıtlamaktadır, bu nedenle mikrobiyom konusu son zamanlarda daha fazla çalışmanın konusu haline gelmiştir (McFall-Ngai ve ark. 2013). Mikrobiyomun metabolizma, bağırsak homeostazı ve bağışıklık gelişimi gibi insan sağlığı ve hastalığının çeşitli bölümleriyle yakından ilişkili olduğu bildirilmiştir (Tasnim ve ark. 2017). Her bireyin mikrobiyomu benzersizdir, ancak genel sağlığı sürdürmek için tutarlı ve çeşitli bir bağırsak mikrobiyotasına sahip olmak gerekir. Bağırsak mikrobiyotası, fizyolojik ve metabolik süreçlere yardımcı olan metabolitlerin üretilmesinden sorumludur ve aynı zamanda kommensallere karşı bağışıklığı korurken, patojenlere karşı koruyucu bağışıklığın gelişmesine yol açan lokal ve sistemik bağışıklık tepkilerini ayarlamaktadır (Tasnim ve ark. 2017). Öte yandan, bağırsak mikrobiyotasının dengesizliği (disbiyoz) genel sağlığı sürdüren önemli faaliyetleri bozabilir ve gastrointestinal, kardiyovasküler, otoimmün ve metabolik bozukluklar gibi hastalıklarla ilişkili olabilir (Jandhyala 2015). Bu olgu ışığında, bağırsak mikrobiyomu hayati bir organ olarak kabul edilir ve mikrobiyal ekosistem içindeki dengenin bozulması ciddi kronik hastalıklara ve gelecekte sağlık sonuçlarına yol açabilir.

Kendi içlerinde de çok çeşitli bir bakteriyofaj topluluğunu içeren, bakteriler, arkeler, mantarlar ve virüslerden oluşan istikrarlı ve geniş kapsamlı bir bağırsak mikrobi-

yönlendiren faktörleri izlemek çok karmaşık hale gelebilir (Gyles 2016). Daha doğru modeller geliştirmek için, daha çok konakçının ilişkisine ve filogenilerin belirli mikrobiyal toplulukların büyümesini nasıl yönlendirdiğine odaklanan, evrimsel ve ekolojik çalışmalar yapmak gerekir (Gyles 2016).

Gelecekteki "(Bütüncül) tek sağlık" araştırması; bulaş potansiyelini azaltmak için diyetlerin probiyotiklerle desteklenmesine ek olarak; yaşam ortamındaki çevresel mikropları değiştirerek ya da evcil ve refakatçi hayvanların diyetlerini değiştirerek; hayvanlar, insanlar ve çevre arasında patojenik mikropların yayılmasını azaltmanın yollarına odaklanacaktır. (Gyles 2016).

7. Sonuç

Mikrobiyal ekosistem birçok farklı mikroptan oluşur, ancak en yaygın ve ana bileşenler bakteri, mantar ve virüslerdir. Bu mikroplar, hayvan bedeninin, farklı organlar arasında özel olarak belirli oyuklarda -nişlerde yaşayan sayısız filum ve türün de yaşadığı birçok farklı ekosistemde kendilerine bir alan oluşturur. Su ve hava gibi birçok faydalı mikrop içeren diğer çevresel bileşenlerde olduğu gibi, bitkiler de bu mikroplara barınak sağlar, fakat mikrop içeren bu çevresel bileşenler, aynı zamanda patojenik mikropların yeni bir konakçıyla kolayca temasa geçebileceği kanallar da olabilir. Son olarak, mikroplar ayrıca yüksek tuzlu sular, kaplıcalar ve hidrotermal menfezler gibi olağandışı kaynaklardan da gelebilir. Tüm bu kaynaklar birlikte, mikrobiyom olarak adlandırılan mikrobiyal ekosistemin bir parçasını oluşturan, birçoğu birbirleriyle ve çevreleriyle etkileşime girebilen ve daha önce karşılaştığımız gibi, genellikle bir hayvan konakçısı olabilen, özel bir mikrop yelpazesi sağlayacaktır. Bağırsakların en zengin ve en çeşitli mikrobiyal ekosistemlerden birini oluşturduğunu öğrendiğimiz için, insanlar da mikrobiyom konusunda bir istisna değildir.

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Bağırsak Mikrobiyotasının Belirleyicileri

Arunachalam Muthaiyan

1. Giriş

Son yıllarda, insan mikrobiyotası, biyomedikal bilimlerdeki en sık odaklanılan dinamik araştırma alanlarından biridir. Özellikle, insan vücudunun mikrobiyotasının çoğunu barındıran gastrointestinal (GI) yolu incelemek için daha fazla çaba sarf edilmiştir (Huttenhower ve diğerleri 2014; Schmidt ve diğerleri 2018; Jalili-Firoozinezhad ve diğerleri. 2019). İnsan mikrobiyotası, bir insan vücudunun içinde ya da üzerinde yaşayan ve konağın sağlığını etkileyen bakteriler, arkeler, ökaryotik mikroplar, bakteriyofajlar ve ökaryotik virüslerin de dahil olduğu mikroorganizmalar topluluğudur (Hooper ve Gordon2001; Huttenhower ve diğerleri 2012; D'Argenio ve Salvatore 2015; Wang ve diğerleri 2017;Hugon ve diğerleri 2017; Lederer ve diğerleri 2017). Bununla birlikte, ilginç bir şekilde, sağlıklı insan mikrobiyotası araştırmaları büyük ölçüde bakterilere odaklanmaktadır ve diğer mikrobiyal alanlara daha az önem verilmektedir (Lloyd-Price ve ark. 2016). Bu mikrobiyal toplulukla ilişkili genler, insan mikrobiyomu olarak adlandırılır ve bilim adamları, mikrobiyotanın bileşimini ve işlevini tanımlamak için mikrobiyomu kullanır (Amato 2017). İnsan mikrobiyomu; mikrobiyal genleri, gen ürünlerini ve mikrobiyotanın genomlarını içeren belirli bir mikrobiyotanın tüm genomik öğelerinin toplanmını kapsar (Proctor 2011) (Kutu 1).

Kutu 1 Mikrobiyota mı Mikrobiyom mu?
"Mikrobiyota" terimi, bakteriler, arkeler, ökaryotik mikroplar, bakteriyofajlar ve belirli bir ortamda (örn. deri ve gastrointestinal sistem) bulunan ökaryotik virüsler de dahil tüm mikroorganizmaları ifade eder. "Mikrobiyom", mikrobiyota genomlarının tümü olarak tanımlanır. Bu mikroorganizmlar, bunların genleri ve metabolitleri, mikroorganizmaların birbirileri ile ve ayrıca konakçıları ile toplu olarak etkileşimleri mikrobiyomumuzu temsil eder. Bu iki terimin küçük farkları olsa da, mikrobiyota ve mikrobiyom sıklıkla birbirinin yerine kullanılır.

İnsan vücudu, biri ebeveynlerden miras kalan ve diğeri mikrobiyomdan elde edilen iki genom taşır. Bu kavram, insanların "holobiont" veya "süper organizmalar" olarak tanımlanmasının temelidir (Cavalier-Smith 1992; Grice ve Segre 2012; Walsh vd. 2014; van de Guchte vd. 2018). Ulusal Sağlık Ortak Fonu Enstitüleri, insan-mikro-

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Diyetin İnsan Bağırsak Mikrobiyomu Üzerindeki Etkileri ve Sonrasında Konak Fizyolojisi ve Metabolizması Üzerindeki Etkisi

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1 Giriş

Bağırsak mikrobiyomu, insan ve hayvanların gastrointestinal sisteminde yaşayan temel olarak bakterilerden oluşan bir mikrobiyal ekosistemdir. Konak genetiğinin, diyet ve çevre de dahil olmak üzere çeşitli faktörlerden etkilendiği düşünülmektedir (Zoetendal ve ark. 2001). Bağırsak mikrobiyomu, bağışıklık sisteminin düzenlenmesi, organ gelişimi, konak metabolizması (Sommer ve Bäckhed 2013), ve bağırsak mukozasının yapısal bütünlüğünün korunması da dahil olmak üzere konak için hayati önem taşıyan birçok işlevi yerine getirir (Jandhyala ve ark. 2015). Son zamanlarda, bağırsak mikrobiyomunun davranışları bile değiştirebildiği bulunmuştur (Sommer ve Bäckhed 2013). Bağırsak mikrobiyotasının metabolik gücü karaciğerinkine eşittir ve genetik potansiyeli, tek başına insan vücudununkinden iki kat daha fazladır (Sommer ve Bäckhed 2013); bu nedenle, insan bağırsak mikrobiyomu genellikle ek bir organ olarak kabul edilmektedir (Sommer ve Bäckhed 2013; O'Hara ve Shanahan 2006; Quigley 2013; Clarke ve ark. 2014). Bağırsak mikrobiyomunun inflamatuar bağırsak hastalığı (IBD), astım, obezite, diyabet (Shen ve Wong 2016) ve kardiyovasküler hastalıklar (Sandoval ve Seeley 2010) gibi hastalıklarda rol oynadığı düşünülmektedir. Mikroplardan yoksun hayvanlar üzerinde yapılan çalışmalarla, bağırsak mikrobiyomunun gerçekten de bağışıklıkta rol oynadığı belirlenmiştir (O'Hara ve Shanahan 2006; Shen ve Wong 2016). Normal bağırsak mikrobiyomu öncelikle Firmicutes ve Bacteroidetes filumlarından oluşur (Sommer ve Bäckhed 2013; Jandhyala ve diğerleri 2015), ancak Proteobacteria, Verrucomicrobia, Aktinobakteriler, Fusobacteria ve Cyanobacteria üyeleri de mevcuttur (Sommer ve Bäckhed 2013).

Bağırsak mikrobiyomunun konak metabolizması işlevlerine yoğun katkısının bilinmesine rağmen (Sommer ve Bäckhed 2013; Quigley 2013; Clarke ve diğerleri 2014; Faderl ve diğerleri 2015), mekanizma tam olarak anlaşılamamıştır (Sommer ve Bäckhed 2013). Bağırsak mikrobiyotası besinler, ksenobiyotikler ve safra asitleri de dahil olmak üzere bileşenlerin metabolizmasına yaptığı katkının yanı sıra kısa zincirli yağ asitleri, K vitamini, B vitamini bileşenleri gibi diğer önemli bileşenlerin üretimine de

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Bağırsak Florası ve Bağırsak Sağlığı Üzerine Probiyotikler ve Prebiyotikler

Mengfei Peng, Nana Frekua Kennedy, Andy Truong, Blair Arriola, ve Ahlam Akmel

1. Giriş

Bağırsaktaki tüm bakteri türleri simbiyotik ilişki içinde yaşar ve diğer bağırsak mikropları ve konakçıları ile karşılıklı mutualistik ilişkiler paylaşır. Bağırsak mikroflora simbiyozunun en büyük etkenlerinden biri diyettir. Sağlıklı bir gastrointestinal mikrobiyom, diyet çeşitliliğine bağlıdır. Bağırsak, sindirilmemiş veya sindirilmiş, bağırsakta bulunan milyonlarca mikrobiyotik türün her biri tarafından farklı şekillerde dönüştürülebilen enerji ile doludur. İnsanlar, anne sütünü tüketirken ilk bağırsak mikrofloralarını geliştirmeye başlarlar, bu sırada bağırsak mikroorganizmasındaki çeşitlilik, özellikle de kommensal bakteriler dengeli bir bağırsak mikrobiyomu oluşmasını sağlar. Katı yiyecekler sunulduğunda, daha egzotik bakteriler ortaya çıkar ve bağırsakların yerleşik ortamı değişmeye başlar. Sıvı bir diyetten katı bir yetişkin diyetine geçiş yapan küçük çocuklar, süreç boyunca yeni yiyeceklerin test edilmesi nedeniyle potansiyel olarak kendi ebeveynlerinden daha çeşitli bir bağırsak mikrobiyomuna sahip olabilirler. Ebeveynlerin yaşam tarzlarının bir sonucu olarak alışılagelmiş diyetleri de çocuklarının kişiselleştirilmiş mikrobiyomunu yaratmaya katkıda bulunabilir.

Çalışmalar, lif ve polifenoller gibi birçok diyet faktörünün bağırsak bakterilerinin dengesini değiştirebileceğini göstermiştir. Örneğin, lif karışımlı bir formüle sahip diyet uygulayan denekler üzerinde yapılan bir çalışmada, bağırsak sıkışmalarına ilişkin daha az olumsuz semptom bulunmuştur, özellikle lifsiz bir diyet uygulayan kontrol grubuna kıyasla bağırsak bakteri kaybı miktarında daha küçük bir azalma görülmüştür (Koecher ve ark. 2015). Ayrı bir çalışmada, diyet polifenollerinin, orijinal bitki ürünlerine kıyasla dönüşüm ürünleri aracılığıyla bağırsak bakteri dengesini dolaylı olarak etkileyebileceği bulunmuş ve kontrol grubuna kıyasla bağırsakta bakteri çoğalmasının artmasına neden olabileceği ifade edilmiştir (Zhang ve ark. 2015). Karbonhidratlar, proteinler ve yağlar çoğu diyete dahil edilen ana bileşenlerdir. Yağ, protein ve karbonhidrat miktarı ve türünün bağırsak mikrobiyotasının bileşiminde büyük rol oynadığı bilinmektedir. Bütirat ve asetatın; proteinlerin, yağların ve karbonhidratların mikrobiyal bozunmasının biyoaktif metabolitleri olduğu ve ayrıca konakçıda bağırsak sağlığı üzerinde olumlu etkileri olduğu bilinmektedir (Riaz Rajoka ve ark. 2017).

şitli çalışmalar, prebiyotikler ve probiyotikler birlikte uygulandığında olumlu gelişmiş etkiler göstermiştir (Markowiak ve Ślizewska 2017). Sinbiyotiklerin etkileri hakkında sınırlı sayıda çalışma olduğundan, prebiyotikler ile probiyotikleri birleştirmenin etkilerini anlamak için daha fazla çalışmaya ihtiyaç vardır (Markowiak ve Ślizewska 2017). Fekal mikrobiyota ve bakteriyel konsorsiyum nakilleri söz konusu olduğunda, bağırsak florasının başarılı bir şekilde düzenlendiğini gösteren çalışmalar vardır, ancak bağışıklık tepkisi prosedürünün nasıl etkilediğini anlamak için daha ileri çalışmalara hala ihtiyaç vardır ve ayrıca enterik enfeksiyonların ve kronik bağırsak iltihaplarının gelecekteki tedavisi için transplantasyonun iyileştirilmiş dağıtım/uygulama yöntemleri de gereklidir (Li ve ark. 2015, 2016).

6. Sonuç

Bağırsak mikrobiyotasına bakıldığında, bağırsağın homeostaz yeteneğinden,bağırsağın genel bağışıklığına, geniş düzenlemelerin bağırsak mikroflora simbiyozuna yol açmasına ve bağırsak mikrobiyal disbiyozunun insanlarda akut ve kronik sağlık sorunları üzerindeki etkilerine kadar değişen birçok faktör analiz edilebilir. Hastalık tedavisi ve müdahale stratejileri için kullanılmak üzere bağırsak mikrobiyotamızı değiştirme ve düzenleme kaabiliyeti son derece güçlüdür ve sürekli olarak gelişmektedir. Probiyotik suşların ve prebiyotik benzeri gıda bileşenlerinin kullanımında gözlemlenen çeşitli faydalar arasında; bağırsak sağlığının iyileştirilmesi, bağışıklık tepkisinin güçlendirilmesi, serum kolesterolünün düşürülmesi ve kanserin önlenmesine yardımcı olunması yer alır. Yararlı mikropların hedefi, SCFA'lar ve K vitamini gibi biyoaktif metabolitlerin üretildiği mekanizmalar olabilir. Ayrıca yararlı mikroplar; lenfoid dokularla etkileşim yoluyla bağışıklık sistemini geliştirirler; teepitel, fagositoz ve IgA salgılanmasını indükler, T-hücre yanıtlarını değiştirir ve Th1 hücrelerini artırır ve Th2 yanıtlarını değiştirirler. Ayrıca, yeni bir alan olan fekal mikrobiyota transplantasyonu ve şu anda geliştirilmekte olan ve iyileştirilmekte olan bakteriyel konsorsiyum transplantasyonu da bağırsak mikrobiyotasını disbiyozdan kurtarmak için umut verici terapötik stratejilerdir.

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İnsan Beslenmesinde ve Bağırsak Sağlığında Bağırsak Florasının Rolü

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1. Giriş

Bağırsak mikrobiyomu üzerine yapılan çalışmaların artmasıyla birlikte, bağırsak mikrobiyomunun hayvan ve insan sağlığını koruyan en önemli faktörlerden biri olduğunu gösteren daha fazla veri ortaya çıkmıştır. Bağırsak mikrobiyomunun rolleri son derece çeşitlidir, ancak sindirim sürecine nasıl dahil olduğuna ve konakçı beslenmesine nasıl katkıda bulunduğuna çok dikkat edilmiştir (Laparra ve Sanz 2010). Konak ve onun mikrobiyomu arasında gerçekleşen dinamikleri ve bu etkileşimin spesifik sonucunun ne olacağını tam olarak anlamak için hala pek çok araştırma yapılmaktadır (Hillman ve ark. 2017). Bağırsak mikrobiyomu, gastrointestinal sistem içinde belirli bölgelerde yaşayan çok çeşitli bir mikrop ekosisteminden oluşur, ancak dış faktörlerden büyük ölçüde etkilenebilir, bu da bağırsak mikrobiyomunu çok değişken ve çeşitli hale getirir. İklim, kimyasallara, minerallere ve kirliliklere maruz kalma gibi çevresel faktörlerin dikkate alınması önemlidir, ancak konakçının tükettiği gıda, gastrointestinal sistemdeki mikroplarla doğrudan temasa geçerek, potansiyel olarak metabolizmalarını ve büyümelerini etkiler. Benzer nedenlerle, mikrobiyom, belirli alanlarda bulunacak mikrop grupları ve sayılarının ne olabileceği açısından bireyden bireye farklılık gösterebilir. Buna ek olarak, genetik gibi konakçıya özgü faktörler ve konakçı hücrelerle etkileşim ve bunların ne gibi bir etki yaratacağı gibi faktörler de bulunmaktadır.

Konağı ve mikrobiyomunu etkileyecek birçok değişkeni dikkate alırken, bağırsak mikrobiyotasında olması gereken mikroorganizmaların optimal oranları için evrensel bir standart bulmanın çok zor olduğunu ve bu sistemlerde sürekli olarak rol oynayan birçok dış ve iç faktörün hesaba katılması gerektiğini belirtmek önemlidir. Bununla birlikte, şimdiye kadar birikmiş olan toplu bilgi ile, sağlıklı bir bağırsak mikrobiyomunu teşvik etmek için genel kılavuzlar olarak kullanılabilecek belirli parametreler tanımlanmıştır. Bu yönergeler göz önünde bulundurularak, dengeli bir bağırsak mikrobiyomunun faydalarını ortaya çıkarmak için belirli kişiler tarafından belirli önlemler uygulamaya konulabilir (Hemarajata ve Versalovic 2013). Ayrıca, belirli mikrop gruplarının topluluk içinde sahip oldukları farklı rolleri anlamak; konakçıya fayda sağlama potansiyelleri ve sağlığa zararlı olabilecek bu mikropların etkisini nasıl azaltılacağı hakkında önemli bilgiler verir.

iyileşmeyecektir, buna soğuk algınlığı, grip (grip), bronşit, çoğu öksürük türü, bazı kulak enfeksiyonları, çoğu sinüs enfeksiyonları ve mide gribi de dahildir (Yoon ve Yoon 2018). Antibiyotiklerin ne zaman, hangi yaşta, ne sıklıkta, ne dozajda ve hangi hastalıklar için kullanılması gerektiğinin farkında olmak önemlidir.

10 Sonuç

Bağırsak mikrobiyomunun beslenmeyi iyileştirmede ve konakçının sağlığını geliştirmede oynadığı rol çok yönlü ve karmaşıktır. Yıllar boyunca, egzersiz, stresin azaltılması, daha iyi bir diyet ve belirli bileşiklerin tüketimi gibi birçok alışkanlık, daha sağlıklı yaşam tarzlarının destekleyicileri olmakla ilişkilendirilmiştir. Ancak mikrobiyomun konakçı ile nasıl etkileşime girdiğinin daha iyi anlaşılmasıyla, bu uygulamaların insan bağırsağında yaşayan mikrobiyal popülasyonu doğrudan nasıl etkileyebileceği hakkında daha fazla bilgi keşfedilmiştir. Bu eylemlerden elde edilen faydaların çoğu, mikrobiyotadan doğrudan yanıt olarak ortaya çıkar. Ancak, bu süreçlerin çoğunun uzun vadeli etkilerini anlamak için hala çok fazla araştırmaya ihtiyaç olduğunu belirtmek önemlidir. Mikrobiyom içinde bir denge olması gerekir ve araştırmalar, bağırsaktaki herhangi bir bakteri grubunun aşırı bolluğunun, bağırsak mikrobiyomunun faydalarından yararlanmak için yapılan her türlü çabayı boşa çıkaran disbiyoza yol açabileceğini göstermiştir. Aynı doğrultuda, bu faydaların çoğunun, belirli mikrobiyal profillere ve diğer dış faktörlere bağlı olarak kişiden kişiye değişeceğini belirtmek önemlidir. Bazı bireylerin sağlıklarını iyileştirmek için özel ihtiyaçları olabilir veya farklı bir yaklaşım gerektirecek bir durumda olabilir. Daha fazla araştırma, konakçı için daha iyi bir sonuç elde etmek üzere bağırsak mikrobiyomunu korumak ve etkilemek amacı ile daha iyi yönlendirilmiş uygulamaların geliştirilmesine yardımcı olacaktır, ancak şu anda kesinlikle yararlı olduğu kanıtlanmış ve bireylerin günlük yaşamlarında uygulanabilecek birçok önlem vardır.

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Enflamasyon ve Kronik Enterik Enfeksiyonlarda Bağırsak Mikrobiyomu

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1. Giriş

İnsan vücudu, kendi hücrelerinden ortalama 10 kat fazla olan yaklaşık 10.000 türde trilyonlarca mikroorganizma barındırır (Eckburg ve ark. 2005; Savage 1977). Bu mikroplar topluca insan mikrobiyomu olarak bilinir ve bunlar genellikle insan vücudunun olası her bölümünde uyum içinde yaşayan bakterileri, virüsleri, protozoaları ve mantarları içerir; mikrobiyom, insan beyninin ağırlığından 2 kg daha ağırdır (Hallen-Adams ve Suhr 2016). İnsan vücudunun yaklaşık %2'sini oluşturan küçücük bir kiracı olan bu mikroorganizmalar, konakçıya bazen "ekstra organ" olarak kabul edilen pek çok fayda sağlar. İnsan Mikrobiyom Projesi (HMP), insan bağırsak mikrobiyotası hakkında kapsamlı bilgi edinmek için 2007 yılında başlatılmıştır. HMP'nin sonuçlarının, mikrobiyomun insan sağlığı, bağışıklık, beslenme ve hastalıktaki rolünün daha iyi bir açıklamasını vermesi beklenmektedir.

Sağlıklı bir şekilde dengelenmiş bir bağırsak mikroflorası; bağırsak bariyer fonksiyonunun korunmasına, bağışıklık sistemini eğitmeye ve olgunlaştırmaya, iltihabı önlemeye, besinler ve reseptör proteinler için patojenlere karşı doğrudan rekabet etmeye, hormon ve vitaminler (örneğin, K vitamini, biyotin ve folat) üretmeye yardımcı olur (Marchesi 2014). ; McKenney ve Pamer 2015). Üç ana bileşen (konak bağışıklığı, patojen ve konağın bağırsak mikrobiyotası) arasındaki karmaşık sürekli etkileşim, enterik enfeksiyonlara yol açabilir. Karmaşık etkileşimin verimliliğine bağlı olarak, enterik enfeksiyon çözülebilir veya enfekte konağın kronik patojen kolonizasyonuna ve hatta konağın ölümüne yol açabilir (Sekirov ve Finlay 2009). Bağırsak mikrobiyotası, beklenmedik bir şekilde patojenlerin kolonizasyonunu destekleyen metabolitler üreterek akut veya kronik enterik enfeksiyonları teşvik edebilir. Simbiyotik *Bacteroides thetaiotaomicron*, *Clostridium rodentium*'u rekabetçi bir şekilde dışlayabilir, ancak bağırsak epitel dokusunun müsinin sialik asit parçalarından süksinat üreterek *Clostridium difficile*'nin kolonizasyonuna yardımcı olabilir (Ferreyra ve diğerleri 2014; Ng ve diğerleri. 2013; Rolhion ve Chassaing 2016). *C. difficile* ayrıca bağırsak ortamındaki endosporlardan gelişmek için safra tuzunu da kullanabilir (Giel ve ark. 2010). Dihidrojen ve etanolamin (bir nitrojen kaynağı olarak) gibi bağırsak mikrobiyomunun çeşitli diğer

kan sonuçlar, gıda alerjileri ve hassasiyetlerinin kaynağı olarak bağırsak mikrobiyomunu işaret etmeye devam etmektedir. Bağırsak bariyerinin nasıl çalıştığını ve nasıl hasar görebileceğini anlamak, alerjilerin nasıl ortaya çıktığını açıklayabilir. Bu aynı zamanda romatoid artrit ve lupus gibi otoimmün hastalıkların daha iyi anlaşılmasını sağlayabilir (Mudd ve Brenchley 2016). Bu, bugünün tedavi edilemeyen hastalıklarına gelecekte çare bulma ümidini göstermektedir.

5. Sonuç

İnsan vücudunun önemli bir bileşeni olarak bağırsak mikroorganizmalarının rolü, sağlık ve hastalıklarda daha belirgin hale gelmektedir. Bunların uygun biyoaktif metabolitler ve farmabiyotik molekül kaynakları oldukları zaten tespit edilmiştir. Ancak belirtmek gerekir ki, insan modellemesi olmadıkları için bugüne kadar edindiğimiz bilgiler öncelikle in vitro ve in vivo hayvan modeli çalışmalarına dayanmaktadır. Bir insan vücudu, bağışıklık sistemindeki, genetik arka plandaki, çevredeki, yaştaki, bağırsak yapısındaki ve en önemlisi, kronik metabolik hastalıklardan nöronal bozukluklara kadar birçok komplikasyona yol açabilen yerli bağırsak mikrobiyal bileşimindeki varyasyonla ilişkili olabilecek bağırsak mikrobiyal bileşiminde oluşan herhangi bir bozulmaya farklı tepkiler gösterir. İnsanlarda mikrobiyal kolonizasyon tarihinin tam olarak anlaşılmasının, öbiyozu sürdürmek ve birçok istenmeyen hastalığı önlemek için etkili stratejiler tasarlamaya yardımcı olacağı varsayılmaktadır.

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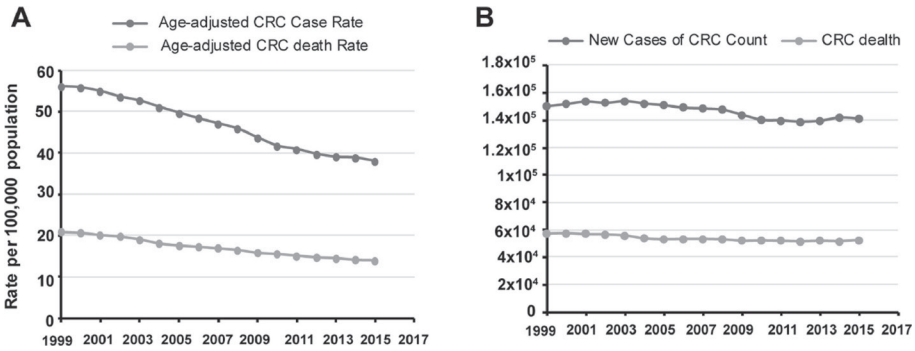
Kolorektal Kanserde Bağırsak Mikrobiyomunun Rolü

Xiaolun Sun

1 Kolorektal kanser (CRC) epidemiyolojisi

Kalın bağırsak, sindirim sistemi uzunluğunun sadece %20'sini ve mukozal yüzey alanının %6'sını oluşturmasına rağmen (Helander ve Fandriks 2014), kolorektal kanser (CRC), gastrointestinal (GI) kanalda teşhis edilen bir numaralı kanserdir ve kolorektal kanser; Amerika Birleşik Devletleri'ndeki (ABD) yeni GI kanserleri vakalarının %44'ünden fazlasını oluşturmaktadır (Siegel ve diğerleri 2019). Neyse ki, yaygın kolonoskopi taraması ve araştırmaların ilerlemesiyle, yaşa göre düzeltilmiş yeni CRC vakalarının oranı 1999'da 100.000 nüfusta 56'dan 2015'te 100.000 nüfusta 38'e (CDC2019) tutarlı bir şekilde düşmüş, ancak toplam vaka sayıları 1999'da 150.014'ten 2015'te 140.788'e kadar gerilemiştir (Şekil 1a). Tutarlı bir şekilde, yaşa göre ayarlanmış CRC ölüm oranı, 1999'da 100.000 nüfus başına 21'den 2015'te 100.000 nüfus başına 14'e düşmüş, ancak toplam vaka sayıları 1999'da 57.222'den 2015'te 52.396'ya kadar gerilemiştir (Şekil 1b). Sonuç olarak kolorektal kanser, hem erkek hem de kadınlarda tüm kanserlerin üçüncü en yaygın nedenidir ve ABD'de kansere bağlı ölümlerin ikinci önde gelen nedenidir (Siegel ve ark. 2019). Bu nedenle, CRC'nin yeni vakalarını ve ölüm oranlarını önemli ölçüde azaltmak için gidilecek uzun bir yol olduğu görülmektedir ve CRC'nin altında yatan mekanizmayı araştırmak ve yeni terapötik yaklaşımları keşfetmek acil bir meseledir.



Şekil 1. 1999-2015 yılları arasında yaşa göre belirlenmiş CRC yeni vakaları ve ölümleri. (a) Amerika Birleşik Devletleri'ndeki yeni CRC vakalarının ve ölümlerin oranları. (b) CRC'den kaynaklanan yeni vaka ve ölümlerin toplam sayıları

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Bağırsak Mikrobiyotası ve Ateroskleroz Riski: Mekanizmalar ile ilgili Güncel Anlayış

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1. Giriş

İnsan bağırsağında, konağın normal işleyişi için gerekli olan çok sayıda komensal ve ortak yaşayan mikroorganizma bulunur (Aron-Wisnewsky ve diğerleri 2012; Bäckhed ve diğerleri. 2004; Cani ve diğerleri. 2012; Cox ve Blaser 2013; den Besten ve diğerleri. 2013; Le Chatelier ve diğerleri. 2013; Nicholson ve diğerleri. 2005; Tremaroli ve Bäckhed 2012). Bağırsak mikrobiyotası olarak adlandırılan bakteri, arke, mantar, virüs ve diğer protozoonlardan oluşan bağırsağın kolonizasyonu, milyonlarca yıl boyunca meydana gelen ortak evrimsel bir sürecin sonucudur (Aron-Wisnewsky ve diğerleri 2012; Bäckhed ve diğerleri. 2004; Cani ve diğerleri. 2012; Cox ve Blaser 2013; den Besten ve diğerleri. 2013; Le Chatelier ve diğerleri. 2013; Nicholson ve diğerleri. 2005; Tremaroli ve Bäckhed 2012). Bu organizmalar konaktan besin alırlar, kompleks karbonhidratların sindiriminde konakçıya yardımcı olurlar, bağışıklık sistemini hassas bir şekilde düzenlerler, metabolik ve enerji homeostazını korurlar, fırsatçı patojenlere karşı koruma sağlarlar ve hatta nörogelişime yardımcı olurlar (Aron-Wisnewsky ve diğerleri 2012; Bäckhed ve diğerleri. 2004; Cani ve diğerleri. 2012; Cox ve Blaser 2013; den Besten ve diğerleri. 2013; Le Chatelier ve diğerleri. 2013; Nicholson ve diğerleri. 2005; Tremaroli ve Bäckhed 2012). İlginç bir şekilde, doğumdan önce steril olan bağırsak, erken kolonize edicileri, doğum sırasında annenin fiziksel teması yoluyla edinir (Palmer ve ark. 2007; Dominguez-Bello ve ark. 2010). Bağırsağın barındırdığı trilyonlarca mikroorganizmanın çoğu, bileşimleri sindirim sistemi boyunca değişen zorunlu anaeroblardır (Aron-Wisnewsky ve ark. 2012; Fouhy ve ark. 2012). Yüksek verimli dizileme (HTS: high throughput sequencing) çalışmalarının ve biyoinformatik araçların geliştirilmesi; yaş, cinsiyet, genetik yapı ve çevresel etkilere dayalı olarak bağırsak mikrobiyotasının bileşiminde bireyler arası farklılıkları aydınlatmada devrim niteliğinde olmuştur (Fouhy ve diğerleri 2012; Li ve diğerleri 2014; Parkhill 2013; Santiago ve diğerleri 2014). Mikrobiyotadan elde edilen metabolitlerin taranması, metatranskriptomikler ve metaproteomikler gibi çeşitli modern yaklaşımlar; bağırsak mikrobiyomunu ve onun ateroskleroz ile ilişkisini daha iyi anlamak için büyük bir veri havuzundan yararlanmanın yollarını sağlar (Nicholson ve ark. 2005; Gosalbes ve

TMAO seviyelerini azaltarak ve hepatik safra asidi neo-sentezini artırarak TMAO'ya bağlı aterosklerozu zayıflattığını bulmuşlardır (Chen ve ark. 2016).

8 Sonuç

Ateroskleroz multifaktöriyel kronik inflamatuar bir hastalıktır. Bu nedenle, kesin altta yatan mekanizmaları aydınlatmak zordur. Bununla birlikte, son bulgular, bağırsak mikrobiyotası ile ateroskleroz da dahil olmak üzere çok sayıda metabolik hastalığın patogenezi arasında bir bağlantı olduğunu göstermiştir. Çalışmalar, mikrobiyotanın; plak gelişimi, bağışıklık sistemini aktive etme, lipid ve kolesterol metabolizmasını değiştirme, arter duvarında iltihaplanmaya neden olma ve bakteriyel metabolitlerin üretimi gibi çoklu mekanizmalar yoluyla aterosklerozu etkileyebileceğini göstermektedir. Bağırsak mikrobiyota transplantasyonu ile ilgili deneysel çalışmalar ile insanlarda ve farelerde bağırsak mikrobiyotasının kompozisyonunun analizi, spesifik bağırsak mikrobiyal suşlarının bolluğunun değişmesinin aterojenez ile ilişkili olduğunu göstermektedir. Çeşitli hayvan modellerinde yapılan son araştırmalar; prebiyotikler, probiyotikler, antibiyotikler ve bağırsak mikrobiyotasını hedef alan küçük moleküller kullanılarak ateroskleroz gelişiminin başarılı terapötik manipülasyonunu bildirmiştir. Bununla birlikte, klinik ortamında kardiovasküler hastalıklar için bağırsak mikrobiyota hedefli tedavinin rutin uygulamasını görmeden önce, uzun bir yol katedilmesi gerekmektedir. Disbiyoz ve ateroskleroz arasında kesin ilişkiler kurmak için büyük prospektif klinik çalışmaların garanti edildiği bir aşamadayız. Ek olarak, bağırsak mikrobiyomunu hedef alan terapötikleri uygulamadan önce hastalıkla ilişkili temel bakteri taksonlarını ve metabolitleri belirlemek önemlidir.

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Bağırsak Mikrobiyomu ve Mikrobiyal Patojenlerle Enterik Enfeksiyonlarda Rolü

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1. Giriş

Enterik enfeksiyonlara tipik olarak enterik bakteriler neden olur. Bakteriler insan veya hayvan vücuduna girer ve akut enterik hastalıklara neden olmak için bağırsaklara gider. Enterik bakterilerin bazı yaygın örnekleri *Escherichia coli, Vibrio cholerae*, *Shigella* ve S*almonella enterica*'dır. Ana giriş yolu ağızdır, çünkü bu organizmalar en yaygın olarak kontamine yiyecek veya suda bulunur. Kontamine gıda tüketildiğinde patojen organizmalar anında vücuda girer ve istila süreci başlar. Kontamine gıda mideye ulaştığında, sindirimin bir sonucu olarak midenin pH'ı yükselir. Midedeki pH yükseldiğinde, bazı bakteriler hayatta kalabilir ve sindirim sisteminin bir sonraki kısmı olan ince bağırsağa geçebilir. Neyse ki, mide suyu, patojenik organizmaların kolonize olmak için aşması gereken tek engel değildir. Vücudun bağışıklık hücrelerinin %70 kadarı ince bağırsağın içinde, özellikle ileumda (ince bağırsağın son kısmı) bulunur. Bu bağışıklık hücreleri, Peyer yamaları adı verilen kitleler halinde kümelenir. Kitleler lenfoid foliküllerdir ve bağırsakların bağışıklık sensörleri olarak kabul edilirler (Jung ve ark. 2010). Luminal antijenleri ve bakterileri taşıma yetenekleriyle tanınırlar. Peyer yama hücreleri, kommensaller ve patojenler arasındaki karmaşık etkileşimler, vücutta doğuştan gelen ve adaptif bağışıklığın oluşmasını sağlar.

Ayrıca, patojenik organizmaların mikrobiyal bariyer olarak adlandırılabilecek bir engeli aşması gerekir. Patojenik organizmaların kolonize olmaya başlamak için bağırsakta kendilerine yer açmaları gerekir. Bağırsaklar normalde patojenik organizmaların rekabet etmek zorunda olduğu kommensal bakteriler tarafından kolonize edilir. Rolhion ve Chassaing'e (2016) göre, mikrobiyal bariyer "bağırsak bakterilerinin, diğer türlerin yeni bakterilerinin veya aynı türün diğer suşlarının istilasını önlemek için bir bariyer oluşturduğu mekanizmadır. Bu düşünce, *Clostridium difficile* enfeksiyonu gibi antibiyotik kullanımından kaynaklanan çeşitli enfeksiyonlarla ve ayrıca birçok enterik patojenin mikropsuz koşullar altında (bağırsak mikrobiyotasının yokluğunda) veya antibiyotik tedavilerini takiben farelerde daha güçlü hastalığa neden olduğu gözlemiyle iyi bir şekilde örneklenir. Rolhion ve Chassaing (2016) tarafından gözlemlendiği üzere bu, alt bağırsak yolunun etkili bir koruma mekanizmasıdır. Bu bariyer, bağır-

12 Sonuç

Bağırsak mikrobiyomu, simbiyotik bir ilişki sürdürmek için birbirleriyle ve konakçılarıyla etkileşime giren bir organizmalar topluluğudur. Bakteriler, virüsler, mantarlar ve diğer mikroskobik organizmalar, insanların ve diğer hayvanların bağırsaklarındaki kaynaklar için sürekli olarak işbirliği yapmakta ve rekabet etmektedir. Bu etkileşimler simbiyotik olabilir ve konakçı için faydalı olabilir ve hatta insan konakçı için zararlı olabilir. Mikrobiyom, yalnızca bağırsak sağlığına değil, insan sağlığına da tüm yönleriyle katkı sağlayarak bu alanda araştırma yapılmasının önemini ortaya koymaktadır. Bu mikropların insan yaşamının çeşitli yönleri üzerinde sahip olabileceği sağlık ve zindelik etkilerini daha iyi anlamak için araştırmalara ihtiyaç vardır. Dünyadaki tüm mikropları yok edecek bir felaket, insanlar üzerinde geniş kapsamlı etkilere sahip olacaktır. Bakterisitlerin, mantar öldürücülerin ve virüs öldürücülerin insan uygulamaları üzerinde, olumlu etkileri var gibi görünse de, zararlı yan etkileri de olabilir. Artan antibiyotik direnci uzun vadeli araştırmaların önemini göstermektedir. Uzun vadeli araştırmalar, antibiyotik direncini azaltmanın ve antibiyotik gerektiren hastalıkları tedavi etmenin daha iyi yollarını aydınlatabilir.

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Obezite ve Kilo Kaybında Antibiyotik Tedavisi ve Bağırsak Mikrobiyomu Üzerine Etkisi

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1. Giriş

Gastrointestinal hastalıkların sayısındaki artış, Amerika Birleşik Devletleri'nde ciddi bir sorun haline gelmiştir. Milyonlarca insana Crohn hastalığı, inflamatuar bağırsak sendromu (IBS), ülseratif kolit ve diğer gastrointestinal sorunlar teşhisi konmaktadır (Kappelman ve ark. 2012; Locke III ve ark. 2004). Bu bozuklukların tümü, gastrointestinal sistemde bulunan mikropların dengesizliği ile ilişkilendirilmiştir. Bağırsak disbiyozu diğer olumsuz etkilere neden olabilir ve obezite de dahil olmak üzere çeşitli sağlık sorunlarına neden olabilir. Çocuklarda ve yetişkinlerde obezite son yıllarda önemli ölçüde artmıştır. Aşırı antibiyotik kullanımı ve Batı tarzı diyet, Amerika Birleşik Devletleri'nde obezite artışının temel nedenleri arasında görülmektedir. Sentetik antibiyotiklerin keşfi tıpta bir dönüm noktası olarak kabul edilebilir. İnsanlar için ölümcül olduğu düşünülen enfeksiyonlar ve salgınlarla savaşarak yaşam beklentisini büyük ölçüde arttırmıştır. Belirli hastalıkları tedavi etmek veya hastalarda birçok hastalığın kontrolüne yardımcı olmak için farklı kategorilerdeki antibiyotikler kullanılır. Enfeksiyonu tedavi etmedeki etkinlikleri nedeniyle, dünya çapındaki popülasyonlar birçok tıbbi komplikasyon için antibiyotiklere güvenmiştir. Hastalara her yıl artan bir oranda antibiyotik reçete edilmektedir, Hastalık Kontrol ve Önleme Merkezleri (CDC), 2016 yılında yalnızca Amerika Birleşik Devletleri'nde 270,2 milyon antibiyotiğin satıldığını belirtmiştir (CDC 2017; Durkin ve ark. 2018). Bununla birlikte, bu uzun süreli antibiyotik kullanımının antibiyotik direncini ve bağırsak mikrobiyotasının dengesizliğini de içeren bazı sonuçları vardır. Gelişmiş ülkelerdeki çoğu insan, enfeksiyonları tedavi etmek için antibiyotiklere baş vurarak daha fazla bağımlı hale gelmektedir. Bu durum, bazı bakteriyel enfeksiyonlarda başarılı olabilse de, antibiyotiklerin kısa ve uzun vadeli aşırı ve yanlış kullanımı kronik sonuçlara yol açabilir (Pichichero 1999; McGowan Jr 1983). Bu inceleme, antibiyotik tedavisi kavramını ve antibiyotik direncinin yanı sıra bağırsak mikrobiyomu üzerindeki etkisini açıklamayı amaçlamaktadır. Bu bölümde; bağırsak disbiyozu, obezite ve diğer mide-bağırsak hastalıkları tanımlanacak ve aynı zamanda enfeksiyonların sentetik antibiyotikler kullanılmadan tedavi edilmesi için alternatif yöntemler de gösterilecektir.

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Proteomik Araştırmalarının Konak Bağırsak Mikrobiyotasına Etkisi

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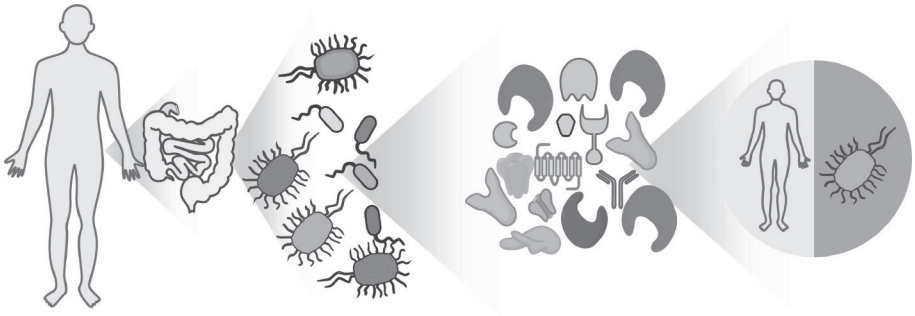
1. Giriş

Mikroplar tüm ekosistemlerde bulunur ve biyojeokimyasal döngü ile insan sağlığında önemli roller oynarlar. İnsan vücudu, vücudun farklı kısımlarını kolonize eden trilyonlarca mikrobun varlığında işlev görür. Ortalama bir insan vücudunda tahmini 37 trilyon hücre vardır ve mikrobiyomun biraz daha fazla hücreden oluştuğu ve ortalama sayının 39 trilyon olduğu tahmin edilmektedir (Sender ve ark. 2016). İnsan bağırsağının mikroplar tarafından kolonizasyonu, insan ve bağırsak mikrobiyotası arasındaki ilişkinin birlikte evriminin bir sonucudur (Şekil 1). İnsan bağırsağında bulunan mikroplar "bağırsak mikrobiyotası" ve bunlar tarafından ifade edilen genler veya proteinler "bağırsak mikrobiyomu" olarak adlandırılır (Turnbaugh ve ark.2006,2007). Genel olarak, bu tür ilişkiler simbiyotiktir ve bağırsak, mikrobiyal hücreler ile konakçı hücreler arasında dinamik bir etkileşim için karmaşık bir ortam sağlar (Moeller ve ark. 2016). Bu etkileşim, normal doğum sonrası gelişimden yetişkin sağlığına kadar insan fizyolojisinin birçok yönünü modüle eder (Moeller ve diğerleri 2016; Gordo 2019).



Şekil 1. İnsan bağırsağı mikrobiyomu analizi tipik olarak, bağırsaktan izolatların (Tablo 1'de mukozal lümen ara yüzünün dışkı malzemeleri) örneklenmesi yoluyla gerçekleştirilir. Ortaya çıkan protein izolatları, insan hücrelerinin yanı sıra karmaşık bir bakteri topluluğundan elde edilir.

İnsan sağlığı, bağırsakta yaşayan mikropların bileşiminden olumlu veya olumsuz etkilenebilir (Mohajeri ve ark. 2018). Değişen bağırsak mikrobiyomları obezite, diya-

belirlemek için kritik adımlardır. Bu, doldurulması zor bir alandır ve büyük işbirlikçi çabalar gerektirecektir. Peptitlerin tandem MS spektral kütüphanelerini oluşturmak ve kullanmak için çabalara ihtiyaç vardır. Ayrıca protein ekstraksiyonu, LC-MS numune hazırlama, depolama ve LC-MS verilerinin biyoinformatik analizi de dahil olmak üzere bağırsak mikrobiyolojik analizi için proteomik iş akışını standartlaştırmaya ihtiyaç vardır. Mikrobiyom alanında proteomik uygulamaların çoğaldığına dair şüphe yoktur, ancak bu tekniğin potansiyel faydalarını tam olarak gerçekleştirmek için ele alınması gereken birçok zorluk vardır. Yüksek kaliteli ve kapsamlı bir spektral kütüphane veritabanı oluşturmak ve mevcut iş akışlarına tutarlı spektral kütüphane arama araçlarını eklemek, bu alanı ilerletmek için kritik öneme sahiptir. Bağırsak mikrobiyotası ve insan sağlığı arasındaki bağlantıya dair artan kanıtlarla birlikte, gelecekteki çalışmalar, bağırsak mikrobiyotası ve mikrobiyom temelli terapötiklerin geliştirilmesi hakkında işlevsel bilgiler sağlamak için sıralı genomların ve spektral kütüphane veritabanlarının artan kullanılabilirliği ile birlikte gelişmiş analitik ve hesaplama araçlarından tam olarak yararlanacaktır.

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Bağırsak Florasının Modülasyonu ve Hayvansal Gıda Ürünlerinde Uygulanması

Zajeba Tabashsum, Vinod Nagarajan, and Debabrata Biswas

1. Giriş

Bağırsak mikrobiyotası, hayvan sağlığını etkileyen en önemli faktörlerden biri haline gelmiştir. Dengeli bağırsak mikrobiyotası enfeksiyona karşı direnci arttırır. Öte yandan, bağırsak mikrobiyotası bozulduğunda dirençteki azalma fark edilir; bu nedenle bağırsak mikrobiyotasının dengelenmesi konak sağlığı için önemlidir (Belkaid ve Hand 2014). Dengeli ve bozulmuş bağırsak popülasyonlarının kompozisyonları net olmasa da, Lactobacilli ve Bifidobacteria türleri strese duyarlı görünmektedir ve bu popülasyonlar bir hayvan stres altındayken azalma eğilimindedir (Conlon ve Bird 2014).

Bitki yan ürünleri, prebiyotikler ve/veya probiyotikler ve hayvan kaynaklı ürünler de dahil olmak üzere biyoaktif bileşikler; diğer faydalı özelliklerinin yanı sıra anti-inflamatuar, antimikrobiyal, antikanserojenik, antioksidan ve vazodilatör özellikleri ile sağlığın iyileştirilmesinde rol oynar (Boivin ve ark. 2007; Tzounis ve diğerleri 2011; Salaheen ve diğerleri 2014a, 2015, 2017). Bu fayda verici aktivitelerin mekanizmaları henüz açıklığa kavuşturulmamıştır, ancak olasılıklardan biri bağırsak/bağırsak mikrobiyotasının modülasyonudur (Hernández ve ark. 2004). Yine, gözlemsel ve epidemiyolojik çalışmalar, konvansiyonel hayvanların çekumlarının mikrobiyal topluluklarında organik benzerlerine göre farklılıklar olduğunu göstermiştir (Torok ve ark. 2011; Mancabelli ve ark. 2016). Antibiyotik büyüme arttırıcıların (AGP) mikropsuz hayvanlar üzerindeki nötr etkileri, hayvanlarda büyümenin desteklenmesinde AGP'ye bağlı bağırsak mikrobiyota modülasyonunun önemini göstermiştir (Turnbaugh ve ark. 2006). İki baskın bakteri filumunun, Bacteroidetes ve Firmicutes›in kilo alımı ile ilişkisi, daha sonraki diğer çalışmalarla desteklenmiştir (Mancabelli ve diğerleri 2016; Singh ve diğerleri. 2013). Diğer bir çalışmada, AGP ile beslenen tavukların bağırsağında *Lactobacillus* türleri, Clostridiales ve Enterobacteriaceae bolluğunun arttığı görülmüştür (Gong ve ark. 2008). Ayrıca *Firmicutes/Bacteroidetes* (F/B) oranı, çiftlik hayvanlarının kilo alımı ve çeşitli ürünlerin terapötik rolü arasında bir ilişki olduğu bildirilmiştir (Singh ve ark. 2013).

Fruktooligosakarit (FOS) ürünleri (oligofruktoz ve inülin), transgalaktooligosakkaritler, glukoligosakkaritler, glikooligosakkaritler, laktuloz, laktitol, maltooligosakka-

ve/veya probiyotiklerin hayvan beslenmesinde destek olarak kullanılması, hayvan sağlığı ve performansını iyileştirmede bağırsak mikrobiyotasını modüle etmek için umut verici bir yaklaşım olabilir, çünkü takviyeler ayrıca yararlı bakteri türlerinin büyümesini teşvik ederek ve spesifik patojenik bakteri suşlarını azaltarak bizi daha güvenli gıda ürünlerine yönlendirebilir. Doğal bitki yan ürünlerinin, prebiyotiklerin ve/veya probiyotiklerin hayvan beslenmesinde takviye olarak kullanılması, hayvan sağlığını ve performansını iyileştirmek için bağırsak mikrobiyotasını modüle etmekte umut verici bir yaklaşım olabilir. Takviyeler ayrıca yararlı bakteri türlerinin büyümesini teşvik ederek ve spesifik patojenik bakteri türlerini azaltarak bizi daha güvenli gıda ürünlerine yönlendirebilir. Çeşitli çalışmalar, bu ürünlerin hayvan yemine eklenmesinin sadece büyümeyi artırmakla kalmayıp aynı zamanda et kalitesini de büyük ölçüde iyileştirdiğini göstermiştir. Bu nedenle, artık bağırsak florasının gıda hayvanlarının büyümesi ve genel kalitesi üzerindeki etkisini belirlemek için laboratuvar/alan denemelerini teşvik etmek gerekmektedir. Ayrıca, bağırsak mikrobiyal popülasyonunu modüle etmede bağırsak mikrobiyotası ve çeşitli yem takviyeleri arasındaki etkileşimleri daha iyi anlamak için gelecekteki deneyler metagenomik, transkriptomik ve proteomik yaklaşımlara odaklanmalıdır. Yakın gelecekte, daha fazla araştırma, yem takviyelerinin bağırsak bakteri popülasyonlarını nasıl modüle ettiğini ve besi hayvanları üretimi ve güvenliğinde nasıl daha etkili olabileceklerini açıklayacaktır.

Kaynaklar

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