TÜRKİYE VE DÜNYADA TARLA BİTKİLERİ YETİŞTİRME VE ISLAHI

Editör: Prof. Dr. Mustafa YILMAZ

yaz
yayınları

Türkiye ve Dünyada Tarla Bitkileri Yetiştirme ve Islahı

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2025

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E_ISBN 978-625-8574-32-6

Aralık 2025 – Afyonkarahisar

Dizgi/Mizanpaj: YAZ Yayınları

Kapak Tasarım: YAZ Yayınları

YAZ Yayınları. Yayıncı Sertifika No: 73086

M.İhtisas OSB Mah. 4A Cad. No:3/3
İscehisar/AFYONKARAHİSAR

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YEM BİTKİLERİNDE BULUNAN BAZI SEKONDER METABOLİTLERİN RUMİNANT SAĞLIĞINA ETKİLERİ

Mustafa YILMAZ[1]

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1. GİRİŞ

Bitkilerde doğal olarak bulunan sekonder metabolitler, kuraklık, ultraviyole radyasyonu ve patojenlere karşı savunmada rol alan düşük molekül ağırlıklı organik bileşiklerdir (Barry ve ark., 2001; Singh ve ark., 2003). Başlıca grupları tanenler, saponinler, flavonoidler, alkaloidler ve fenolik bileşiklerdir (Yılmaz, 2018; Ebrahim ve Negussie, 2020). Bu bileşikler, yem bitkilerinde yalnızca çevresel adaptasyonda değil, ruminant beslemede de önemli biyolojik işlevlere sahiptir (Kılıç ve ark., 2017). Ruminantların rumen mikrobiyotası, bu bileşiklerin etkilerini belirleyen temel faktördür (Ku-Vera ve ark., 2020). Tanenler protein yıkımını sınırlandırarak sindirilebilirliği artırır, saponinler protozoa popülasyonunu azaltarak metan üretimini düşürür, flavonoidler ise antioksidan özellikleriyle oksidatif stresi azaltır (Barry ve ark., 2001; Ebrahim ve Negussie, 2020; Tedeschi ve ark., 2021).

Son yıllarda yapılan çalışmalar, bu bileşiklerin yem kalitesi, hayvan refahı ve çevresel sürdürülebilirlik açısından önemli olduğunu göstermektedir (Yılmaz, 2018; Tedeschi ve

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ark., 2021; Besharati ve ark., 2022). Uygun düzeylerde kullanıldıklarında metan salınımını azaltma, bağışıklığı destekleme ve ürün kalitesini artırma etkileri bildirilmiştir (Kılıç ve ark., 2017; Ku-Vera ve ark., 2020). Ancak yüksek konsantrasyonlarda enzim inhibisyonu, sindirim azalması ve toksisite riski görülebilir (Bacaksız ve Azman, 2022). Bu nedenle sekonder metabolitlerin kullanımı, doz-etki ilişkisi dikkate alınarak dikkatle planlanmalı ve bilimsel verilere dayalı yem formülasyonlarına entegre edilmelidir.

2. SINIFLANDIRMA

2.1. Tanenler

2.1.1. Tanenlerin Kimyasal Yapısı ve Sınıflandırılması

Tanenler, bitkilerde sekonder metabolit olarak bulunan geniş bir polifenolik bileşik grubudur. Bitkilerin savunma mekanizmalarında görev alan bu bileşikler, yem bitkilerinde ve otlatma sistemlerinde ruminant beslemesi açısından önemli biyolojik etkilere sahiptir (Besharati ve ark., 2022). Tanenler genel olarak iki ana sınıfa ayrılır:

1. Hidrolize tanenler (HT): Gallik veya ellagik asit esterlerinden oluşur ve asidik ya da enzimatik reaksiyonlarla kolayca hidrolize olabilirler (Besharati ve ark., 2022).

2. Kondanse tanenler (KT, proantosiyanidinler): Flavan-3-ol (örneğin kateşin, epikateşin) birimlerinin polimerleridir. C–C bağlarıyla birbirine bağlandıkları için hidrolize edilmeleri zordur ve genellikle daha yüksek moleküler ağırlığa sahiptirler (Besharati ve ark., 2022).

Kimyasal açıdan tanenlerin proteine bağlanma kapasitesi büyük önem taşır. Kondanse tanenler; pH, moleküler ağırlık, polimerizasyon derecesi ve hidroksil grubu sayısına bağlı olarak proteinlerle hidrofobik etkileşimler veya hidrojen bağları yoluyla

kompleks oluşturabilir. Bu özellik, rumen ve bağırsak ortamında tanenlerin fizyolojik etkilerini belirleyen temel mekanizmalardan biridir (Min ve ark., 2003).

2.1.2. Rumen Fizyolojisi Açısından Tanenlerin Etki Mekanizmaları

2.1.2.1. Rumen proteolizi ve azot metabolizması

Ruminantlarda rumendeki mikroorganizmalar, proteini parçalayarak amonyak ve mikrobiyal protein oluşturur. Bu süreçte rumende çözünebilir (ERDP) ve çözünmeyen protein (RUP) dengesi önemlidir. Kondanse tanenler bu dengeyi iki yönlü etkiler. Orta düzeyde tanen içeren yemler, proteinle bağlanarak aşırı parçalanmayı sınırlar; böylece RUP artar ve azot kullanımı iyileşir (Min ve ark., 2003). Ayrıca rumende amonyak (NH_3-N) oluşumu azalır, bu da azot kaybı ve çevresel kirlilik riskini düşürür (Besharati ve ark., 2022). Ancak tanen düzeyi aşırı olduğunda, mikrobiyal aktivite ve sindirilebilirlik azalır. Bu nedenle optimum tanen seviyesi, verimli azot kullanımı için kritik öneme sahiptir (Fonseca ve ark., 2023).

2.1.2.2. Rumen mikrobiyotası, uçucu yağ asitleri ve metan üretimi

Tanenler yalnızca proteoliz üzerinde değil, aynı zamanda rumen mikrobiyotası ve fermantasyon ürünleri üzerinde de etkilidir. Başlıca mekanizmalar şunlardır:

- Protozoa popülasyonunda azalma: Bazı kondanse tanen (KT) kaynaklarının protozoa sayısını düşürdüğü, bu yolla metanojen archaea ile olan simbiyotik ilişkiyi zayıflatarak metan (CH_4) emisyonunu azalttığı bildirilmiştir (Min ve ark., 2021).
- H_2 arzının azalması: KT takviyesi, metan sentezi için gerekli olan hidrojenin (H_2) azalmasına ve alternatif H_2 tüketim yollarının (örneğin asetogenez) artmasına neden

olabilir. Bu da CH_4 üretiminde düşüşe yol açabilir (Soldado ve ark., 2021).

- Uçucu yağ asidi (UYA) profili değişimi: Tanen içeren rasyonlarda asetat/propiyonat oranında düşüş ve propiyonat yönünde kayma gözlenmiştir; bu da enerji verimliliğini artırabilir (Poli ve ark., 2025).
- Fiber sindiriminde azalma: Yüksek tanen konsantrasyonları, NDF ve ADF sindiriminin düşmesine yol açarak rasyonun enerji değerini olumsuz etkileyebilir (Besharati ve ark., 2022).

2.1.2.3. Yem tüketimi, sindirilebilirlik ve hayvan performansı

Tanenlerin ruminant beslemede kullanımı, fayda–risk dengesi dikkate alınarak değerlendirilmelidir. Orta düzeyde kondanse tanen içeren yemler, yem tüketimini genellikle etkilemez veya hafif düzeyde azaltır. Ancak yüksek tanen içeriği (>50 g/kg ya da %5 KM) durumunda yem alımı azalır ve performans düşer (Besharati ve ark., 2022).

Doz-yanıt ilişkisine göre, %1.5–4 KM düzeyinde tanen kullanımı, süt ve et veriminde olumlu etkiler oluşturabilir. Bununla birlikte, etkinin hayvan türü, üretim dönemi, yem bileşimi ve tanen kaynağına bağlı olarak değişebileceği bildirilmektedir (Mueller-Harvey ve ark., 2019).

2.1.3. Potansiyel Faydalar ve Uygulama Alanları

2.1.3.1. Azot kullanımı ve çevresel etki

Tanenlerin önemli bir avantajı, azotun rumende aşırı parçalanmasını engellemesi sayesinde idrar azotu kaybının azalması ve çevresel azot yükünün düşürülmesi potansiyelidir. Örneğin, bir meta-analiz tanen kullanımının azot kaybını sınırlandırdığını göstermiştir (Besharati ve ark., 2022). Bu durum özellikle nitrojenli gübrelerin kullanımının yaygın olduğu tarım

ve hayvancılık sistemlerinde, çevresel sürdürülebilirlikle doğrudan ilişkilidir.

2.1.3.2. Süt ve et kalitesi, sağlık üzerindeki etkiler

Orta düzeyde tanen içeren yemlerin, süt üre azotunu azaltıp mikrobiyal protein akışını artırarak, süt verimi ve bileşimini iyileştirdiği bildirilmektedir (Besharati ve ark., 2022). Ayrıca kondanse tanenlerin düşük moleküler ağırlıklı metabolitleri, bağırsak düzeyinde oksidatif stresi azaltarak antioksidan kapasiteyi destekler (Soldado ve ark., 2021).

Min ve ark. (2003), kondanse tanen içeren özellikle korunga (Onobrychis viciifolia Scop.) gibi türlerin gastrointestinal nematodlara karşı baskılayıcı etki gösterdiğini; bunun da parazit gelişimini sınırlayıp bağırsak mukozasını koruyarak yemden yararlanmayı artırdığını bildirmiştir.

2.1.4. Potansiyel Riskler

Tanenlerin yararlarının yanı sıra bazı sınırlayıcı yönleri de vardır. Yüksek tanen içeriği (>≈ %5 KM veya >50 g/kg KM) yem tüketimini azaltarak kuru madde ve enerji sindirimini düşürebilir (Besharati ve ark., 2022). Aşırı stabil tanen–protein kompleksleri, ince bağırsakta parçalanmayı engelleyip amino asit emilimini azaltabilir; bu durum özellikle yüksek polimerizasyonlu tanenlerde görülür (Min ve ark., 2003). Türler arası adaptasyon farkları vardır; örneğin geyikler tükürüklerindeki prolin zengin proteinlerle tanen etkilerini azaltabilirken, sığır ve koyunlarda bu mekanizma daha zayıftır (Besharati ve ark., 2022). Tanen kaynağı ve ekstraksiyon farklılıkları, yem formülasyonunda standardizasyon ve tat sorunları oluşturabileceği bildirilmiştir. (Yanza ve ark., 2021).

Özetle, uygun dozlarda kondanse tanenler, rumen proteolizini sınırlandırır, azot kullanımını iyileştirir, metan salınımını azaltır ve antioksidan–antimikrobiyal etkiler sağlar.

Ancak etkinin düzeyi kaynak, doz, tür ve yem bileşimine bağlı olduğundan dengeli formülasyon gerektirir.

Tablo 1. Bazı bitkilerde tanen tipi ve biyolojik etkileri

Bitki	Tanen Tipi	Ortalama İçerik (% KM)	Biyolojik Etki
Korunga (*Onobrychis viciifolia*)	Kondanse	8-12	CH_4 ↓, RUP ↑, Antihelmintik
Keçiboynuzu (*Ceratonia siliqua*)	Kondanse	6-9	Protein korunumu, NH_3-N ↓
Meşe Palamudu (*Quercus spp.*)	Hidrolize + Kondanse	10-15	Antioksidan ↑, Yem tüketimi ↓
Sumak (*Rhus coriaria*)	Hidrolize	12-20	Antioksidan, Antimikrobiyal
Çay (*Camellia sinensis*)	Kondanse	10-18	Metan ↓, Mikrobiyal denge ↑

Min ve ark., 2003; Besharati ve ark., 2022; Ebrahim ve Negussie, 2020

2.2. Saponinler

2.2.1. Kimyasal Yapı, Sınıflandırma ve Bitkisel Kaynaklar

Saponinler, lipofilik bir aglikon (sapogenin) çekirdeği ile buna bağlı bir veya daha fazla şeker zinciri (glikoz, ramnoz, galaktoz vb.) içeren yüzey-aktif glikozit bileşiklerdir. Bu yapı onlara emülsifiye edici ve hemolitik özellik kazandırır (Hostettmann ve Marston, 1996; Cheok ve ark., 2014). Doğada iki ana gruba ayrılırlar:

1. *Triterpenik saponinler*: 30 karbonlu pentasiklik çekirdeğe sahiptir ve özellikle yonca (*Medicago sativa* L.), bakla (*Vicia faba* L.) ve soya (*Glycine max* L.) gibi baklagillerde yaygındır (Kılıç ve ark., 2017).
2. *Steroidal saponinler:* 27 karbonlu çekirdeğe sahip olup yucca (*Yucca schidigera*) ve quillaja (*Quillaja*

saponaria) ekstraktlarında bulunur (Francis ve ark., 2002; Holtshausen ve ark., 2009).

Bitkilerde genellikle vakuollerde depolanır ve antimikrobiyal, antifungal, antiherbivor işlevler görür (Francis ve ark., 2002). Biyolojik aktiviteleri; aglikon tipi, şeker zinciri sayısı, polarite ve molekül ağırlığına bağlı olarak değişir (Cheok ve ark., 2014).

2.2.2. Rumen Mikrobiyotasına Etki Mekanizmaları

2.2.2.1. Protozoa ve Mikrobiyal Topluluk Üzerine Etki

Rumen; bakteriler, arkea, protozoa ve mantarlardan oluşan karmaşık bir mikrobiyal ekosistemdir. Saponinlerin en belirgin etkisi, protozoa hücre zarındaki sterollerle etkileşimi sonucu ortaya çıkar. Zar geçirgenliği artar, iyon dengesi bozulur ve hücre lizisi gerçekleşir (Francis ve ark., 2002; Goel ve Makkar, 2012). Bu antiprotozoal etki sonucunda:

- Rumen protozoa popülasyonu %40-100 arasında azalabilmektedir (Francis ve ark., 2002; Ramdani ve ark., 2023).
- Protozoa sayısındaki azalma metan üretimini dolaylı olarak düşürmektedir, çünkü protozoalar metanojenik arkealarla simbiyotik ilişki içindedir (Patra ve Saxena, 2009).
- Protozoaların baskılanması, bakteriyel popülasyonun artışına ve rumenden daha fazla mikrobiyal proteinin ince bağırsağa geçişine katkı sağlar (Mao ve ark., 2010).

2.2.2.2. Fermentasyon ve UYA) Üzerine Etki

Saponinler, rumen fermentasyon profilini doğrudan etkileyen bileşiklerdir. Protozoa popülasyonunun azalması, hidrojen (H_2) üretimini düşürür, bu da asetat:propiyonat oranının

azalmasına ve propiyonat oranının artmasına yol açar. Böylece enerji verimliliği artar; çünkü propiyonat glukoneogenezde temel uçucu yağ asididir (Holtshausen ve ark., 2009; Goel ve Makkar, 2012). Ayrıca saponinlerin: amonyak (NH_3-N) konsantrasyonunu azalttığı, mikrobiyal protein sentezini artırdığı, toplam gaz ve metan (CH_4) üretimini düşürdüğü birçok in vitro ve in vivo çalışmada gösterilmiştir (Patra ve Saxena, 2009).

2.2.3. Azot Metabolizması ve Protein Kullanımı

Saponinlerin rumen azot döngüsüne etkisi dolaylı fakat belirgindir. Protozoalar bakterileri fagosite ederek "mikrobiyal geri dönüşüm" oluşturur; bu da rumende amonyak birikimini artırır. Saponinlerin protozoaları baskılaması sonucu; rumende amonyak konsantrasyonu düşer, mikrobiyal protein sentezi artar, azotun feçes (dışkı) formunda atımı artarken idrar yoluyla kaybı azalır, süt ve et gibi hayvansal ürünlerde azotun verimli kullanımı artar (Wina ve ark., 2005).

2.2.4. Bağışıklık Destekleyici Etkiler

Saponinlerin yüzey-aktif yapısı ve polifenolik karakteri, bazı antioksidan özellikler kazandırır. Literatürde saponinlerin; lipid peroksidasyonunu azalttığı, SOD (süperoksit dismutaz), CAT (katalaz), ve GPx (glutatyon peroksidaz) gibi enzimlerin aktivitesini artırdığı gösterilmiştir (Francis ve ark., 2002; Ramdani ve ark., 2023). Ayrıca, saponinler: *Escherichia coli* ve *Clostridium perfringens* gibi rumen ve bağırsak patojenlerine karşı antibakteriyel etki gösterebildiği, makrofaj aktivitesini artırarak bağışıklık sistemini destekleyebildiği ve yumurta çıkışını baskıladığı da bildirilmiştir (Wina ve ark., 2005). Dolayısıyla, düşük-orta dozda saponin kullanımı, sadece rumen mikrobiyal dengesini değil, hayvanın genel sağlığını ve çevresel etkisini olumlu yönde etkileyebilir.

2.2.5. Performans ve Üretim Parametreleri Üzerine Etkiler

2.2.5.1. Süt verimi ve bileşimi

Yucca schidigera ekstraktı içeren rasyonlarla beslenen süt ineklerinde, süt üre azotu (MUN) seviyesinde azalma, süt yağ oranında hafif artış ve toplam süt veriminde belirgin iyileşme rapor edilmiştir. Bu etkilerin, propiyonat oranındaki artış ve azot kullanım verimliliğindeki gelişmelerle ilişkili olduğu düşünülmektedir (Holtshausen ve ark., 2009).

2.2.5.2. Et üretimi ve yem dönüşüm oranı

Saponin katkısı yapılan yemlerle beslenen ruminantlarda (özellikle koyun ve keçilerde), yemden yararlanma oranı artmış, metan kayıpları azalmış ve karkas ağırlığı ile kas gelişimi olumlu etkilenmiştir (Patra ve Saxena, 2009; Ramdani ve ark., 2023). Ancak %1.5 KM'nin üzerinde uygulanan yüksek dozlarda yem tüketiminde azalma ve iştah kaybı gözlenmiştir (Wina ve ark., 2005; Kılıç ve ark., 2017).

2.2.5.3. Çevresel kazanımlar

Saponinlerin metan azaltıcı potansiyeli, ruminant çevre fizyolojisine katkısı bakımından dikkat çeker. Çeşitli in vitro ve in vivo çalışmalar, %0.5 KM oranında saponin katkısının metan üretiminde %10-25 arasında azalma sağladığını göstermektedir (Goel ve Makkar, 2012; Ramdani ve ark., 2023)

Saponinlerin etkileri doz bağımlıdır. Düşük dozlarda faydalı etkiler gösterirken, yüksek dozlarda toksik ve irritatif sonuçlara neden olabilir (Francis ve ark., 2002).

2.2.6. Potansiyel Riskler

- Tat: Sabunsu tat hayvanın yem alımını olumsuz etkileyebilir (Francis ve ark., 2002).

- Membran etkisi: Yüksek konsantrasyonlar eritrosit ve epitel hücrelerinde zar geçirgenliğini artırabilir (Wina ve ark., 2005).
- Kaynak varyasyonu: Bitkisel kaynaklı ekstraktların saponin içeriği tür, iklim ve ekstraksiyon yöntemine göre değişebilir; bu nedenle standardizasyon önemlidir.
- Maliyet: Özellikle saflaştırılmış saponin ekstraktları (*Yucca, Quillaja*) yem katkısı açısından yüksek maliyetlidir.

Sonuç olarak, uygun dozda ve doğru kaynakla kullanıldığında saponinler, sürdürülebilir ruminant beslemede tanenlerle birlikte en umut verici doğal bileşik gruplarından biridir. Çevreye duyarlı, antibiyotik içermeyen ve yüksek verimliliğe sahip hayvancılık modellerinde önemli rol oynayacaktır.

Tablo 2. Bazı bitkilerde saponin tipi ve biyolojik etkileri

Bitki Türü	Saponin Tipi	Ortalama İçerik (% KM)	Biyolojik Etki
Yucca (*Yucca schidigera*)	Steroidal	8-12	Metan ↓, Protozoa ↓, Propiyonat ↑
Quillaja (*Quillaja saponaria*)	Triterpenik	6-10	NH_3 ↓, Mikrobiyal protein ↑
Yonca (*Medicago sativa*)	Triterpenik	1-3	Antioksidan ↑, Bağışıklık ↑
Çemen (*Trigonella foenum-graecum*)	Triterpenik	2-4	İştah ↑, Kolesterol ↓
Soya (*Glycine max*)	Triterpenik	0.5-1.5	Azot dengesi ↑, CH_4 ↓

Wina ve ark. 2005; Holtshausen ve ark., 2009; Patra ve Saxena 2009

2.3. Flavonoidler

2.3.1. Kimyasal Yapı, Sınıflandırma ve Bitkisel Kaynaklar

Flavonoidler, fenilpropanoid yolakları üzerinden sentezlenen, 15 karbonlu (C_6-C_3-C_6) polifenolik bileşiklerdir. İki aromatik halka (A ve B) ile oksijen içeren heterosiklik halka (C) birleşerek temel flavonoid yapısını oluşturur. Bu yapı, flavonoidlerin yüksek redoks potansiyeli, serbest radikal süpürme ve metal şelatlama özelliklerini belirler (Panche ve ark., 2016).

Flavonoidler, yapısal farklara göre şu alt gruplara ayrılır:

- Flavonlar: apigenin, luteolin
- Flavonoller: kuersetin, kemferol
- Flavanonlar: naringin, hesperidin
- Flavanoller: kateşin, epikateşin
- İzoflavonlar: genistein, daidzein

Yem bitkilerinde, özellikle yonca (*Medicago sativa* L.), bakla (*Vicia faba* L.), üçgül türlerinde (*Trifolium* spp.) flavonol ve izoflavonlar yoğun olarak bulunur. Tahıllarda ise sorgum türleri (*Sorghum* spp.), yulaf (*Avena sativa* L.) ve mısır (*Zea mays* L.) flavonoid içermektedir. Bu bileşikler bitkilerde UV koruması, patojen savunması gibi görevler üstlenirken, ruminant beslemede antioksidan, antimikrobiyal ve anti-inflamatuar etkileriyle öne çıkar (Oskoueian ve ark., 2013; Boğa ve ark., 2022).

2.3.2. Flavonoidlerin Biyokimyasal Özellikleri ve Antioksidan Mekanizması

Flavonoidlerin en belirgin biyolojik etkisi, reaktif oksijen türlerini (ROS) süpürerek oksidatif stresi azaltmalarıdır. B halkasındaki 3',4'-dihidroksilasyon yapısı, antioksidan

kapasitenin temel belirleyicisidir (Heim ve ark., 2002). Flavonoidlerin antioksidan etkisi üç ana mekanizma ile açıklanır:

1. Serbest radikal süpürme: DPPH ve ABTS gibi radikalleri nötralize eder.
2. Metal şelasyonu: Fe^{2+} ve Cu^{2+} iyonlarını bağlayarak Fenton reaksiyonlarını sınırlar.
3. Antioksidan enzim aktivasyonu: SOD, CAT ve GPx enzimlerinin ekspresyonunu artırır (Nijveldt ve ark., 2001; Heim ve ark., 2002).

Ruminantlarda bu etkiler, özellikle sıcaklık stresi, yüksek üretim dönemi ve nişasta yönünden zengin rasyonlar altında önem taşır. Ayrıca flavonoidler, süt yağının oksidatif stabilitesini artırarak raf ömrünü uzatabilir (Kılıç ve ark., 2017; Boğa ve ark., 2022).

2.3.3. Rumen Mikrobiyotasına Etkileri

Flavonoidler, rumende biyotransformasyona uğrayarak glikozit formlarından aglikonlara, ardından fenolik asit türevlerine dönüşür. Bu ara ürünler, rumen mikrobiyotasını doğrudan veya dolaylı etkileyebilir (Selma ve ark., 2009). Başlıca mikrobiyal etkiler şunlardır:

- Gram-pozitif bakterilerin gelişimini baskılar, Gram-negatiflerde etkisi sınırlıdır; bu, mikrobiyal çeşitliliğin dengelenmesine katkı sağlar (Duda-Chodak ve Tarko, 2007).
- Proteolitik bakteri aktivitesini azaltarak amonyak oluşumunu sınırlar (Oskoueian ve ark., 2013).
- Kuersetin, metanojenik arkeaları baskılayarak metan üretimini azaltabilir (Xiao ve ark., 2020).

- Firmicutes/Bacteroidetes oranını dengeleyerek enerji üretimi ve UYA profilini iyileştirir (Xiao ve ark., 2020).
- Ayrıca bazı flavonoidler, quorum sensing mekanizmasını etkileyerek patojen bakterileri baskılar (Whitehead ve ark., 2001).

2.3.4. Fermentasyon, Uçucu Yağ Asitleri (UYA) ve Metan Üretimi Üzerine Etkileri

Flavonoidlerin rumen fermentasyonu üzerindeki etkileri, tanen ve saponinlere göre daha selektif olup, özellikle propiyonik asit üretimini artırma ve metan üretimini düşürme yönünde etkilidir. Yapılan çalışmalar flavonoidlerin; oropiyonik asit oranını artırdığını, asetik asit oranını azalttığını, asetat:propiyonat oranını düşürdüğünü, toplam metan üretimini %10-20 oranında azalttığını göstermektedir (Patra ve Saxena, 2011; Oskoueian ve ark., 2013).

Özellikle kuersetin, kateşin ve luteolin gibi flavonoidlerin, metanojenik arkealarda enerji metabolizmasını baskıladığı ve bu etkinin mcrA gen ekspresyonunun azaltılmasıyla ilişkili olduğu bildirilmektedir. Ayrıca flavonoidler, rumendeki proteolitik enzimler ile deaminaz aktivitesini baskılayarak amonyak (NH_3-N) oluşumunu düşürmekte ve bu sayede azot verimliliğini artırmaktadır (Oskoueian ve ark., 2013).

2.3.5. Ruminant Sağlığı, Üretim Performansı ve Ürün Kalitesi Üzerine Etkiler

2.3.5.1. Antioksidan savunma ve bağışıklık sistemi

Flavonoid takviyesi yapılan ruminantlarda (özellikle süt ineklerinde) plazma MDA (malondialdehit) düzeyinde azalma, SOD ve GPx gibi antioksidan enzimlerin aktivitelerinde artış görülmüştür (Liu ve ark., 2023). Bu da hücresel oksidatif stresi azalttığını göstermektedir. Ayrıca flavonoidler, makrofaj

fagositoz kapasitesini ve lenfosit proliferasyonunu artırarak bağışıklık sistemini güçlendirmektedir (Gessner ve ark., 2017).

2.3.5.2. Süt kalitesi

Flavonoid içeren yem katkıları süt yağ asidi profilini olumlu etkilemektedir. Özellikle konjuge linoleik asit (CLA) ve ω-3 yağ asitleri oranını artırmakta, oksidatif bozulmayı azaltmaktadır (Gessner ve ark., 2017). Bu durum hem süt kalitesini hem de insan sağlığı açısından besin değerini yükseltmektedir.

2.3.5.3. Et kalitesi

Flavonoidler, et dokusunda lipid oksidasyonunu azaltır, renk stabilitesini ve su tutma kapasitesini artırır. Özellikle kateşin ve kuersetin takviyesi, karkaslarda lipid oksidasyonu göstergesi olan TBARS (tiyobarbitürik asit reaktif maddeler) değerini düşürerek raf ömrünü uzatmaktadır. Yeşil çay ekstraktı ve kuersetin katkılı rasyonlarla beslenen hayvanların etlerinde daha uzun raf ömrü ve daha düşük bozulma rapor edilmiştir (Tang ve ark., 2002).

2.3.5.4. Reprodüktif fonksiyonlar

İzoflavonlar (özellikle genistein ve daidzein), östrojenik aktivite gösterebilir. Düşük düzeylerde bu etki östrojen reseptörlerini destekleyerek doğurganlığı artırırken, yüksek konsantrasyonlarda fertilite üzerinde baskılayıcı etki yaratabilir (Whitten ve ark., 1995). Bu nedenle özellikle soya ve yonca içerikli rasyonlarda izoflavon düzeyleri dikkatle izlenmelidir.

Genel olarak 200-800 mg/baş/gün (veya 100-400 mg/kg KM) aralığı ruminantlar için güvenli kabul edilmektedir. Aşırı dozlarda yem tüketimi azalabilir ve rumen mikrobiyal aktivitesinde baskılanma görülebilir. Bu nedenle doz kademeli olarak artırılmalı ve performans göstergeleriyle izlenmelidir.

2.3.6. Potansiyel Riskler

- *İzoflavon fazlalığı: Yüksek düzeyde izoflavon içeren yemlerde (özellikle soya ve yonca) uzun süreli kullanım erkek hayvanlarda fertilite sorunlarına yol açabilir (Whitten ve ark., 1995).*
- *Tat sorunu:* Yüksek doz flavonoid acı tat sebebiyle yem tüketimini azaltabilir.
- *Bitkisel çeşitlilik ve ekstraksiyon farkı:* Flavonoid içeriği bitki türüne, hasat zamanına ve ekstraksiyon yöntemine göre değişebilir.
- *Metabolik farklılıklar:* Keçiler gibi küçük ruminantlar flavonoidleri daha hızlı metabolize eder (Min ve ark., 2003), bu da etki süresini kısaltabilir.

Tablo 3. Bazı bitkilerde flavonoid tipi ve biyolojik etkileri

Bitki Türü	Baskın Flavonoidler	Flavonoid İçeriği (mg QE/g KM)	Etki Alanı
Yonca (*Medicago sativa*)	Luteolin, apigenin	3-8	Antioksidan, süt ↑
Bakla (*Vicia faba*)	Kuersetin, kemferol	5-9	CH_4 ↓, azot dengesi
Fiğ (*Vicia sativa*)	Kateşin, epikateşin	4-7	Mikrobiyal denge
Portakal (*Citrus sinensis*)	Hesperidin, naringin	10-20	Antioksidan, bağışıklık ↑
Yeşil çay (*Camellia sinensis*)	Epigallokateşin gallat (EGCG)	30-40	Lipid oksidasyonu ↓, et kalitesi ↑

Tang ve ark., 2002; Oskoueian ve ark., 2013; Panche ve ark., 2016

3. SONUÇ VE ÖNERİLER

Flavonoidler, tanenler ve saponinler gibi sekonder metabolitler, ruminant beslemede antioksidan, metabolik

düzenleyici ve mikrobiyal dengeleyici özellikleriyle öne çıkan doğal katkı maddeleridir. Uygun dozlarda kullanıldıklarında rumen fermentasyonunu optimize eder, metan emisyonunu azaltır, ürün kalitesini artırır ve çevresel sürdürülebilirliğe katkı sağlarlar. Ancak bu etkiler; bileşiğin kaynağı, dozu, hayvan türü ve çevresel koşullara bağlı olarak değişebilir. Bu nedenle, sekonder metabolitlerin yem formülasyonlarına entegrasyonu bilimsel verilere dayalı olmalı ve omik teknolojilerle desteklenmelidir. Gelecekte bu bileşiklerin, antibiyotiksiz ve çevre dostu hayvancılığın geliştirilmesinde stratejik araçlar olarak değerlendirilebileceği öngörülmektedir.

KAYNAKÇA

Bacaksız, O. K., & Azman, M. A. (2022). Tanenler: Silajlarda ve hayvan besleme uygulamalarında kullanımı. Balıkesir *Sağlık Bilimleri Dergisi, 11*(Supplement 1), 64-73.

Barry, T. N., McNeill, D. M., & McNabb, W. C. (2001). Plant secondary compounds; their ımpact on forage nutritive value and upon animal production. *IGC Proceedin*gs (1985-2023), 6.

Besharati, M., Maggiolino, A., Palangi, V., Kaya, A., Jabbar, M., Eseceli, H., De Palo, P., & Lorenzo, J. M. (2022). Tannin in ruminant nutrition: Review. *Molecules, 27*(23):8273.

Boğa, M., Kocadayıoğulları, F., & Can, M. E. (2022). Flavonoid ve Saponinlerin Ruminant Hayvan Beslemede Kullanımı. *Black Sea Journal of Engineering and Science, 5*(1), 34-41.

Cheok, C. Y., Salman, H. A. K., & Sulaiman, R. (2014). Extraction and quantification of saponins: A review. *Food Res. Int.*, 59, 16-40.

Duda-Chodak A., & Tarko T. (2007). Antioxidant properties of different fruit seeds and peels. *Acta Scientiarum Polonorum Technologia Alimentaria, 6*(3), 29-36.

Ebrahim, H., & Negussie, F. (2020). Effect of secondary compounds on nutrients utilization and productivity of ruminant animals: A review. *Journal of Agri. Science and Practice, 5*(1), 60-73.

Fonseca, N. V. B., Cardoso, A. d. S., Bahia, A. S. R. d. S., Messana, J. D., Vicente, E. F., & Reis, R. A. (2023). Additive tannins in ruminant nutrition: an alternative to achieve sustainability in animal production. *Sustainability, 15*(5), 4162.

Francis, G., Kerem, Z., Makkar, H. P. S., & Becker, K. (2002). The biological action of saponins in animal systems: A review. *British Journal of Nutrition, 88*(6), 587-605.

Gessner, D. K., Ringseis, R., & Eder, K. (2017). Potential of plant polyphenols to combat oxidative stress and inflammatory processes in farm animals. *Journal of Animal Physiology and Animal Nutrition, 101*(4), 605-628.

Goel, G., & Makkar, H. P. S. (2012). Methane mitigation from ruminants using tannins and saponins. *Tropical Animal Health and Production, 44*, 729-739.

Heim, K. E., Tagliaferro, A. R., & Bobilya, D. J. (2002). Flavonoid antioxidants: Chemistry, metabolism and structure-activity relationships. J., of Nutritional Biochemistry, 13(10), 572-584.

Holtshausen, L., Chaves, A. V., Beauchemin, K. A., McGinn, S. M., McAllister, T. A., Odongo, N. E., ... & Benchaar, C. (2009). Feeding saponin-containing Yucca schidigera and Quillaja saponaria to decrease enteric methane production in dairy cows. *Journal of Dairy Science, 92*(6), 2809-2821.

Hostettmann, K. & Marston, A. (1996). Saponins. University of Lausanne, Swetzerland, 548p.

Kılıç, Ü., Tekeli, A., & Akyol, N. (2017). Antioksidan özellik gösteren sekonder metabolitlerin hayvan beslemesinde kullanımı. *Kocatepe Veteriner Dergisi, 10(1)*, 79-89.

Ku-Vera J. C., Jiménez-Ocampo R, Valencia-Salazar S. S., Montoya-Flores M. D., Molina-Botero I. C., Arango, J., Gómez-Bravo, C. A., Aguilar-Pérez, C. F. & Solorio-Sánchez, F. J. (2020) Role of secondary plant metabolites on enteric methane mitigation in ruminants. *Frontiers of Veterinary Sci.*, 7:584.

Liu, J., Wang, Y., Liu, L., Ma, G., Zhang, Y., & Ren, J. (2023). Effect of Moringa leaf flavonoids on the production performance, immune system, and rumen fermentation of dairy cows. *Veterinary Medicine and Science, 9*(2), 917-923.

Mao, H. L., Wang, J. K., Zhou, Y. Y., & Liu, J. X. (2010). Effects of addition of tea saponins and soybean oil on methane production, fermentation and microbial population in the rumen of growing lambs. *Livestock Science, 129*(1-3), 56-62.

Min, B. R., Barry, T. N., Attwood, G. T., & McNabb, W. C. (2003). The effect of condensed tannins on the nutrition and health of ruminants fed fresh temperate forages: a review. *Animal Feed Science and Technology, 106*(1-4), 3-19.

Min, B.R., Pinchak, W.E., Hume, M.E., Anderson, R.C. (2021). Effects of condensed tannins supplementation on animal performance, phylogenetic microbial changes, and ın vitro methane emissions in steers grazing winter wheat. *Animals, 11*(8):2391.

Mueller-Harvey, I., Bee, G., Dohme-Meier, F., Hoste, H., Karonen, M., Kölliker, R., Waghorn, G. C. & et al., (2019). Benefits of condensed tannins in forage legumes fed to ruminants: importance of structure, concentration, and diet composition. *Crop Science, 59*(3), 861-885.

Nijveldt, R. J., Van Nood, E. L. S., Van Hoorn, D. E., Boelens, P. G., Van Norren, K., & Van Leeuwen, P. A. (2001). Flavonoids: a review of probable mechanisms of action and potential applications. *American j.,of clinical nutrition, 74*(4), 418-425.

Oskoueian, E., Abdullah, N., & Oskoueian, A. (2013). Effects of flavonoids on rumen fermentation activity, methane production, and microbial population. *BioMed Research International, 2013*(1), 349129.

Panche, A. N., Diwan, A. D., & Chandra, S. R. (2016). Flavonoids: An overview. *Journal of Nutrit. Sci*., 5, e47.

Patra, A. K., & Saxena, J. (2009). The effect and mode of action of saponins on the microbial populations and fermentation in the rumen and ruminant production. *Nutrition Research Reviews, 22(2)*, 204-219.

Patra, A. K., & Saxena, J. (2011). Exploitation of dietary bioactive compounds for improving ruminant production. *Animal Feed Science and Technology*, 166, 1-15.

Poli, C., Tontini, J.F., Jacondino, L.R., Villalba, J.J., Muir, J.P., Tedeschi, L.O. (2025). Plant tannin for grazing ruminant growth. *Animal Frontiers, 15*(3):47-58.

Ramdani, D., Yuniarti, E., ve ark. (2023). Roles of essential oils, polyphenols, and saponins of medicinal plants as natural additives and anthelmintics in ruminant diets: A systematic review. *Animals, 13*(4), 767.

Selma, M. V., Espin, J. C., & Tomas-Barberan, F. A. (2009). Interaction between phenolics and gut microbiota: role in human health. *Journal of Agricultural-Food Chemistry, 57*(15), 6485-6501.

Singh, B., Bhat, T. K., & Singh, B. (2003). Potential therapeutic applications of some antinutritional plant secondary metabolites. *J. of Agricultural Food Chem., 51(19)*, 5579-5597.

Soldado, D., Bessa, R. J. B., & Jerónimo, E. (2021). Condensed tannins as antioxidants in ruminants-effectiveness and

action mechanisms to improve animal antioxidant status and oxidative stability of products. *Animals, 11*(11), 3243.

Tang, S. Z., Kerry, J. P., Sheehan, D., & Buckley, D. J. (2002). Antioxidative mechanisms of tea catechins in chicken meat systems. *Food Chemistry, 76*(1), 45-51.

Tedeschi, L. O., Muir, J. P., Naumann, H. D., Norris, A. B., Ramírez-Restrepo, C. A., & Mertens-Talcott, S. U. (2021). Nutritional aspects of ecologically relevant phytochemicals in ruminant production. *Frontiers in Veterinary Science*, 8, 628445.

Whitehead, N. A., Barnard, A. M., Slater, H., Simpson, N. J., & Salmond, G. P. (2001). Quorum-sensing in Gram-negative bacteria. *FEMS Microbiology Reviews, 25*(4), 365-404.

Whitten, P. L., Lewis, C., Russell, E., & Naftolin, F. (1995). Potential adverse effects of phytoestrogens. *The Journal of Nutrition*, 125, 771S-776S.

Wina, E., Muetzel, S., & Becker, K. (2005). The impact of saponins or saponin-containing plant materials on ruminant production-a review. *Journal of Agricultural and Food Chemistry, 53*(21), 8093-8105.

Xiao, M., Du, L., Wei, M., Wang, Y., Dong, C., Ju, J., Zhang, R., Peng, W., Wang, Y., Zheng Y., & Meng, W. (2025). Effects of quercetin on in vitro rumen fermentation parameters, gas production and microflora of beef cattle. *Frontiers in Microbiology,* 16, 1527405.

Yanza YR, Fitri A, Suwignyo B, Elfahmi, Hidayatik N, Kumalasari NR, Irawan A, Jayanegara A. (2021). The utilisation of tannin extract as a dietary additive in ruminant nutrition: a meta-analysis. *Animals; 11*(11):3317.

Yıldız, B., Öztürk, Y. E., Kardeş, Y. M., Mut, H., & Gülümser, E. (2021). Kaba yem olarak değerlendirilen ökse otunun antioksidan özellikleri ve kondanse tanen içeriklerinin belirlenmesi. *Anadolu Tarım Bilimleri Dergisi, 36*(1), 132.

Yılmaz, M., (2018). Toxic-hazardous substances found in plants in a natural pasture protected from grazing and their effects on animals. *Academic Platform-of Journal Engineering and Science, 6*(1,) 97-103.

PEANUT (*Arachis hypogaea* L.)

Mehmet ÖZ[1]

Order: Rosales

Family: Leguminosae

Genus: Arachis

Species: Arachis hypogaea L. (2n = 4x = 40)

1. INTRODUCTION

Peanut (*Arachis hypogaea* L.) is an annual, warm-season oilseed crop belonging to the Fabaceae family, originating in South America. It plays an important role in agricultural production due to its multiple functions: as a high-quality food source for human consumption, as a feed and forage ingredient in livestock production, and as a biological nitrogen fixer that contributes to soil fertility.

Due to its high oil and protein content, peanuts are primarily used in the production of peanut oil and peanut-based food products, particularly peanut butter. The species is widely cultivated in tropical and subtropical regions worldwide. In addition to being a cost-effective source of dietary protein, peanuts are also rich in essential vitamins and minerals, making them a valuable ingredient in the formulation of numerous food products.

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1.1. Nutritional and Chemical Composition

While the nutritional and chemical composition of peanuts varies depending on the variety, they typically contain 45-55% fat, 20-25% protein, and 16-18% carbohydrates. They also contain approximately 5% minerals. The peanut's fatty acid profile consists primarily of 45-60% oleic acid, 20-40% linoleic acid, and 5-10% palmitic acid. Smaller amounts include 3-7% stearic acid, 1-3% behenic acid, and 0.5-2% arachidic acid.

Nitrogen fixation through a symbiotic association with *Rhizobium* bacteria, peanuts can contribute approximately 4.5–15 kg of nitrogen per hectare to the soil. Peanut meal contains around 50% protein and has a high nutritional value. Stems and leaves can be used as fresh forage or dried for winter feed. Peanut shells are utilized as a feed additive or in particleboard manufacturing. The income derived from peanut stems is roughly one-ninth of that generated from the kernels.

1.2. Uses

Direct consumption: Fresh, dried, or roasted as a snack. Food industry: Used in the production of pastries, confectionery, desserts, chocolate, peanut butter, and peanut oil. Global consumption rate: Approximately 41% of the world’s peanut production is consumed directly as food, with this rate reaching up to 74% in North America.

1.3. Origin and History

Research confirms that the peanut’s center of origin is present-day Brazil and Peru. From there, it spread to other South American countries and subsequently to Africa through early missionaries and explorers. In the 16th century, Spanish traders introduced peanuts to Europe, from where they rapidly reached China and other parts of Asia.

In 1908, additional trials were conducted at the Halkalı School of Agriculture in İstanbul. By 1935, comprehensive research programs began at the Antalya Tropical Crops Research Station (now BATEM – Western Mediterranean Agricultural Research Institute), where work continues to this day. Commercial peanut cultivation in Türkiye began in 1920.

1.4. Classification of Peanut Types

Peanut (*Arachis hypogaea* L.) is classified into four main types based on morphological characteristics and usage: Virginia, Runner, Spanish, and Valencia. In Türkiye, since nearly all peanut production is used for snack purposes, large-seeded Virginia-type varieties are preferred.

2. PEANUT PRODUCTION AND TRADE

In 2022, global peanut production was approximately 49 million metric tons**.** The leading producer was China**,** with a 37.7% share (18.3 million tons), followed by India at 20.6% (10.1 million tons) and Nigeria at 8.7% (4.3 million tons). Türkiye's share of global production was around 0.4% (0.186 million tons).

Looking at export data, the total global export value in 2023 was approximately USD 4.8 billion**.** India was the top exporter with a 19.3% share, with the USA following at 13.8% and Brazil at 8.2%. In the same year, Türkiye's exports were valued at USD 11.5 million, accounting for a 0.3% share.

On the import side, the global value in 2023 was around USD 4.5 billion. The leading importers were China with a 15.3% share, the Netherlands with 13.4%, and Indonesia with 9%. Türkiye's import value was USD 44.7 million, giving it a 1% share and a 19th global ranking.

2.1. Peanut Production and Economy in Türkiye

In 2024, Türkiye produced approximately 246 796 metric tons of in-shell peanuts from a cultivation area of about 57 642 hectares (TÜİK, 2025).

Table 1. Peanut Cultivation Areas, Production, and Yield in Turkiye

Years	Cultivation Area (decares)	Production (tons)	Yield (kg/decare)
1990	240 000	3 000	120
2000	283 000	78 000	276
2020	547 747	215 927	394
2022	457 016	186 340	408
2023	460 098	185 137	402
2024	576 419	246 796	428

According to 2023 TUIK data, peanut production in Türkiye was geographically concentrated as follows: 48.07% in Adana**,** 23.79% in Osmaniye, and 13.04% in Şırnak**.** The rapid increase in peanut cultivation in Şırnak is particularly noteworthy.

Table 2. Ranking of Provinces by Peanut Production in Türkiye

Provinces	Production (tons)	Share (%)
Adana	89 011 tons	48.07%
Osmaniye	44 060 tons	23.79%
Şırnak	24 150 tons	13.04%

In 2024, Türkiye’s domestic peanut consumption was recorded at 240 944 tons. Imports amounted to 15 233 tons, while exports were limited to 289 tons, resulting in a self-sufficiency rate of approximately 94% for peanuts (HUBUDER, 2024).

According to 2025 data from the Seed Registration, Certification and Control Center of the Ministry of Agriculture and Forestry of the Republic of Türkiye, there are 12 registered peanut varieties in the country.

Various research institutes and private companies have registered peanut varieties developed in Turkey. Among the varieties developed by the Western Mediterranean Agricultural Research Institute Directorate are Florispan, Gazipaşa, Çom, NC-07, and Batem-5025. The Faculty of Agriculture at Çukurova University has improved the Sultan and Halisbey varieties. In addition, the Eastern Mediterranean Agricultural Research Institute contributed to the development of the Ayşehanım and Adanur varieties. In the private sector, Polen Seed Industry and Trade Inc. developed the Peggy variety, while Atlas Seed Agriculture Ltd. developed the Masal and Rigel varieties.

3. BOTANICAL CHARACTERISTICS OF PEANUT

The peanut plant exhibits unique botanical features, from its root system and branching habit to flowering, fruiting, and seed development.

Figure 1. Peanut plant and fruits

(https://www.alamy.com/peanut-plant-with-seeds-isolated-on-white-background-image617394948.html).

3.1. Root System

The taproot is well-developed, penetrating 90–120 cm deep, while lateral roots can spread 30–150 cm horizontally. The most active portion for nutrient and water uptake lies within the top 10–25 cm of soil. Pegs (gynophores) that carry developing pods penetrate the soil from branches. Nodules formed on the roots host nitrogen-fixing bacteria.

3.2. Stem and Leaves

Stems are generally 30–60 cm long and branched. Leaves are arranged oppositely in pairs on the stem. Exhibiting phototropism, leaves remain open during the day and close at night.

3.3. Flowering and Pollination

Peanut plants begin flowering 30–45 days after planting. Flowers emerge from leaf axils. Each flower has 10 stamens and 1 pistil. Pollination usually occurs before flowers open, making peanuts predominantly self-pollinating (autogamous). After fertilization, the ovary elongates into a peg (gynophore) that grows downward into the soil. Although a plant may produce 500–1000 flowers, only 8–13% develop into pods.

3.4. Fruit (Pod)

Peanut pods develop underground from fertilized ovaries. The outer shell is fibrous and veined. The shell accounts for 15–45% of pod weight. Each pod contains 1–3 seeds.

3.5. Seed (Kernel)

The edible kernel is the economically valuable part of the plant. The seed coat (testa) can be pink, red, or brown, depending on the variety. The cotyledons (two seed leaves) are nutrient-rich and lack endosperm. Thousand-seed weight ranges from 200 to 1000 g.

3.6. Germination and Emergence

Under suitable conditions (minimum soil temperature of 12°C), peanut seeds germinate 10–12 days after sowing. Immediate germination occurs in cultivars without seed dormancy. The taproot reaches a depth of 10–12 cm within a short period.

In peanuts, the vegetative period ranges from 85–100 days in tropical regions to 130–140 days in temperate zones. In Virginia types, the period is 105–106 days in tropical climates and 160–170 days in temperate climates.

3.7. Flowering and Pollination

Begins approximately 1–1.5 months after sowing and can continue for 2–3 months. Flowers typically open early in the morning. Peanuts are predominantly self-pollinating (autogamous) plants.

Figure 1. Peanut plant growth

(https://www.shutterstock.com/search/groundnut-seeds-germination?dd_referrer=https%3A%2F%2Fwww.google.com%2F).

3.8. Pod Setting and Maturation

After fertilization, other floral parts abscise, and a stalk-like structure called a gynophore (or peg) develops from beneath the ovary. The gynophore, carrying the zygote at its tip, grows downward into the soil, penetrating to a depth of 2–10 cm before

beginning horizontal growth. This horizontal growth culminates in the formation of pods once the ovary is fully embedded in the soil. Pods begin to mature about 60 days after flowering.

Peanut plants may produce 500–1 000 flowers, but only 8–23% develop into pods. In erect cultivars, pegs formed on upper branches often fail to reach the soil, reducing yield; however, pods form in clusters near the crown, facilitating harvest. In prostrate cultivars, yield potential is higher, but pods are scattered, making harvest more laborious and increasing pod losses.

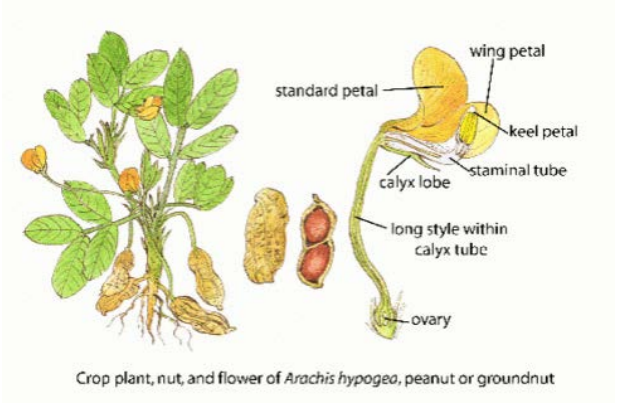

Figure 3. Peanut flower, fruit and gynophore

(https://www.flickr.com/photos/faooftheun/16892004216).

4. PEANUT CULTIVATİON

4.1. Climatic Requirements

Peanuts are summer crops originating from tropical and subtropical regions. For optimal yield and quality, abundant sunlight and high temperatures are essential. A minimum of 12–13°C is required for germination. Higher temperatures positively influence both yield and quality. When air temperature drops below 20°C, plant development slows, necessitating the selection

of early- or late-maturing cultivars depending on the growing region. Approximately 550 mm of evenly distributed rainfall is needed throughout the growing season. Dry, rain-free weather during harvest is critical for obtaining high-quality products. Frost events in spring and autumn are detrimental to peanut cultivation.

4.2. Soil Requirements

Selecting suitable soil is crucial for achieving high yield and quality in peanut production. Sandy or sandy-loam soils with light color, good drainage, and a friable structure are most suitable.

4.3. Gynophore Development

Maintain looseness, enabling fertilized ovaries on gynophores to penetrate and grow easily.

Pod Quality: Promote the development of well-formed, bright, and visually appealing pods.

Harvest Ease: Prevent soil compaction, reducing pod losses and facilitating harvest operations.

Cleanliness: The absence of stones, gravel, or other debris facilitates post-harvest cleaning. Moderately heavy soils can also be productive, provided they are well-prepared and moisture balance is maintained.

4.4. Soil Chemistry and Nutrient Elements

Slightly acidic soils (pH 6.0–6.4) are optimal. Excess nitrogen and potassium should be avoided. Excessive moisture can cause pod rot. In alkaline soils (pH 7.5–8.5), leaf chlorosis and pod darkening may occur.

In Turkey, soils in the Adana and Osmaniye regions are well-suited for peanut cultivation based on these criteria.

4.5. Crop Rotation

Although peanuts hold an important place in crop rotation systems, certain critical factors must be considered to maintain soil fertility.

Peanuts deplete soil nutrients significantly. If post-harvest residues (stems and leaves) are not returned to the soil, nutrient depletion occurs. Research indicates that peanuts may consume more nitrogen than they return to the soil. Soil fatigue caused by peanuts can reduce yields in succeeding crops.

Two-Year Rotation Recommendation for Peanuts: In regions with intensive peanut production, a two-year rotation program can help sustain productivity and soil health. One of the most effective sequences is maize–peanut. Maize enriches the soil due to its high fertilization needs and provides a clean field for peanuts by resisting root-knot nematodes and many other diseases.

If peanuts are to be sown as a second crop, early-maturing winter cereals or rapeseed should be preferred to vacate the field early, ensuring timely peanut sowing.

5. SOIL PREPARATION FOR PEANUT CULTIVATION

Successful peanut production relies heavily on proper soil preparation. A loose and friable soil structure facilitates the penetration of gynophores (peg structures) into the soil and minimizes pod losses during harvest.

5.1. Stages of Soil Preparation

Primary Tillage (Summer or Autumn): Following stubble shredding, the soil is ploughed to a depth of 25–30 cm

using a mouldboard plough. This incorporates organic residues into the topsoil, accelerating their decomposition.

Deep Tillage (Optional): In certain years, subsoiling with a ripper is recommended to break the plough pan.

Weed Control (Winter): If no significant weed infestation is present, additional winter tillage is unnecessary.

Seedbed Preparation (Spring): Implements such as disc harrows, tine harrows, and rollers are used to achieve an optimal seedbed structure for healthy peanut growth.

6. FERTILIZATION IN PEANUT PRODUCTION: PRINCIPLES AND PRACTICES

Although peanuts exhibit a variable response to fertilizers compared to other legumes, appropriate fertilization strategies can substantially enhance yield and quality.

6.1. Nutrient Requirements

For the production of approximately 100 kg of in-shell peanuts and 200 kg of plant residue, average nutrient uptake is as follows: Nitrogen: 6.3 kg, Phosphorus: 1.1 kg, Potassium: 4.6 kg, Calcium: 2.7 kg and Magnesium: 1.4 kg. Up to 80–90% of total potassium, calcium, and magnesium is absorbed by vegetative plant parts rather than pods.

6.2. Fertilization and Plant Development

Fertilization accelerates and prolongs the flowering period. However, excessive fertilization can promote vegetative growth, causing flowers to form higher up on the plant and preventing the gynophores from penetrating the soil. This can reduce the pod set ratio by up to 35%.

6.3. Nitrogen Fertilization

In soils lacking Rhizobia bacteria or in fields where peanuts are being cultivated for the first time, an application of 8-14 kg of nitrogen per decare is recommended. A study on sandy soils showed that yield, which was 145 kg/da with only phosphorus application, increased to 445 kg/da with the addition of 16 kg of nitrogen. In soils with bacterial inoculation, nitrogen fertilizers are generally not required; however, an extra 2-5 kg of nitrogen per decare can be applied during the early growth stage.

6.4. Phosphorus and Potassium Fertilization

As Turkish soils are typically poor in phosphorus, peanuts respond well to this fertilizer. Therefore, it is recommended to apply 6-7 kg of phosphorus per decare. These fertilizers should be incorporated into the soil during seedbed preparation before planting.

6.5. Calcium and Gypsum

In sandy soils, applying 200 kg of gypsum per decare can increase yield by 33%. The effect of liming is limited in soils rich in lime.

Table 3. Regional Recommendations

Region	Nitrogen (kg/da)	Phosphorus (kg/da)
Southeastern Anatolia & Mediterranean	10–20 (AS) / 8–16 (AN)	35–40 (NSP) / 14–16 (TSP)
Aegean Region	15–25 (AS) / 12–20 (AN)	35–40 (NSP) / 14–16 (TSP)

7. SELECTION AND PREPARATION OF PEANUT SEEDS

To achieve high yields in peanut cultivation, it's essential to select seeds properly, store them under suitable conditions, and carefully prepare them for planting.

Medium-sized seeds germinate faster and more healthily than either large or small kernels. Since peanuts are a self-pollinating crop, their genetic purity is high. For seed purposes, it's better to choose mature pods from the lower parts of the plant rather than those on the upper branches. Seeds intended for planting should be dried slowly after harvest, without being exposed to excessive sunlight. Shelling should be done by hand, preferably during the winter months. To preserve seed quality, the moisture content should be kept around 8% for in-shell peanuts and 6% for kernels.

7.1. Preparation for Planting

Seeds that are physically damaged during shelling become susceptible to soil-borne diseases. Therefore, seeds should be treated with fungicides containing 25 g/l Fludioxonil + 10 g/l Metalaxyl-M to protect against root and collar rot diseases. If the soil lacks the proper Rhizobium bacteria, the most effective method is to inoculate the seeds with a bacterial culture. Inoculated seeds should be planted as soon as possible, away from direct sunlight.

Since fungicides are toxic to Rhizobium bacteria, the two should not be applied to the seeds at the same time. Instead, the bacterial culture should be sprayed onto the seed rows during planting, and the seeds should be covered with soil immediately.

7.2. Climate, Soil and Planting Time

The optimal planting time for peanuts depends on climate and soil conditions. Early planting, once the soil has warmed up, yields the best results. Seedlings can tolerate short cold periods, so peanuts can be planted before cotton. While germination can occur at soil temperatures of 10°C, it will be slow, and the seedlings will be susceptible to pests. Temperatures between 15°C and 20°C are ideal for planting. In Turkey, planting can begin in the second half of April.

In large-scale production, planting early, medium, and late-maturing varieties simultaneously can facilitate harvesting, as it creates about a three-week difference in maturation times. Harvesting should not coincide with the rainy season in the autumn.

7.3. Plant Population and Planting Density

A low plant population can limit yield and make maintenance more difficult. Recommended plant populations vary from 10 000–35 000 plants per decare, depending on the variety, climate, and disease risk.

7.4. In-Row Spacing

Yield increases as the distance between rows decreases. In a study in North Carolina, with a consistent 15 cm in-row spacing, a yield of 306 kg/da was achieved with 90 cm row spacing, 340 kg/da with 60 cm, and 361 kg/da with 40 cm. However, planting with a row spacing narrower than 60 cm is difficult with most planters.

7.5. Within-Row Spacing

This has less impact on yield but is important for harvesting and maturation. Denser planting results in smaller plants that are easier to harvest, prevents late flowering, and accelerates maturation, especially in spreading varieties. The

disadvantages of dense planting include more difficult in-row cultivation, an increased risk of fungal diseases, challenging pesticide application, and a higher seed requirement.

Upright and spreading peanut varieties have different space requirements. In upright varieties, pods form in a narrower area, while in spreading types, they form in a wider area. Therefore, upright types require higher plant populations than spreading types. In trials in Turkey, spacings of 90x15 cm (7 400 plants/da) for spreading varieties and 60x15 cm (11 000 plants/da) for upright varieties have yielded very good results. The seeding rate ranges from 3.5-5.5 kg/da for small-seeded varieties and 6.0-10.0 kg/da for large-seeded ones.

7.6. Planting Method

The most ideal planting method for peanuts is row planting with a planter. Peanuts can be easily sown by attaching the appropriate disks to a cotton or corn planter. To prevent seed damage, the tractor's speed should be kept low. Additionally, very dry seeds should have their moisture content increased to 8-9%. The planting depth typically ranges from 3-7 cm, but in heavy soils, it is recommended to plant the seeds shallower.

8. MAINTENANCE PRACTICES

After planting, the soil should be moist, free of weeds, and soft. Thinning of seedlings is also crucial in densely planted fields. Therefore, maintenance practices are very important for correctly performing these processes.

8.1. Breaking the Soil Crust

The top layer of soil is directly exposed to the effects of rain and sunlight. As a result, surface aggregates break down more, the soil surface dries out faster, and compounds that cause hardening accumulate on the surface as water evaporates. Due to

these characteristics, the structure of the top few millimeters of soil differs significantly from the underlying soil mass. This layer, formed on the surface by natural processes such as the impact of raindrops and sun-induced drying, is defined as a soil crust.

This dynamic and complex formation consists of closely packed soil particles that can prevent seeds from germinating and emerging, as well as hindering root development, thus affecting the quantity and quality of the crop. The resistance of the soil crust to seedling emergence significantly affects the germination and sprouting process. Therefore, if this layer forms after sowing, it must be broken or loosened with shallow tillage tools or chemical applications.

8.2. Hoeing and Soil Piling

The first row spacing is done when the plants are about three weeks old. During this process, hoeing should be shallow so as not to damage the plant roots. Seedling thinning is usually done during this period. The second hoeing should be done after or during the slow watering period. The third hoeing should be done before the gynophores enter the soil. Light soil cultivation is done during the second or third hoeing. Soil cultivation is essential for upright varieties.

8.3. Weed Control

There are two critical periods for weed control: the initial stage when the plants are tiny and the period after pod formation. Weeds may appear before the peanuts. In such cases, germinated weeds can be removed using a hand hoe or tractor cultivator. The use of herbicides for weed control is also recommended to reduce hoeing costs and avoid mechanical damage to the plants or gynophores during cultivation.

8.4. Pest and Disease Control

Climate plays a vital role in the development of fungal diseases in peanuts. Among the most common diseases in Turkey are root and stem rot and leaf spot disease caused by Cercospora spp. species. Aflatoxin formation during and after storage is also a significant problem.

Table 4. Active ingredients, application rates, timing, and target weeds for herbicides used in peanuts (bku database, 2025).

Active Ingredient	Application Dose	Application Time	Target Weeds
50 g/l quizalofop-p-ethyl + 38 g/l imazamox	100 ml/da	Post-emergence	Narrow-leaf weeds like Johnsongrass, Bermuda grass, quackgrass, barnyardgrass, and goosegrass.
80 g/l imazamox	62.5 ml/da	Early post-emergence (when weeds have 2-6 leaves)	Barnyardgrass, common pigweed, fumitory, catchweed, smartweed, and groundcherry.
25 g/l imazamox	160 ml/da	Post-emergence (when weeds have 2-4 leaves)	Barnyardgrass, common pigweed, fumitory, catchweed, smartweed, and groundcherry.
480 g/l bentazone	200 ml/da	Post-emergence (when weeds have 2-4 leaves)	Redroot pigweed, lambsquarters, nutgrass, and foxtail.
480 g/l bentazone + 22.4 g/l imazamox	150 ml/da	Post-emergence	Jimsonweed, common pigweed, lambsquarters, foxtail, and black nightshade.

9. HARVESTING METHODS AND DRYING OF PEANUT

9.1. Harvesting Methods

The optimal time for peanut harvesting occurs when soil is sufficiently dry and the weather is favorable. Under these

conditions, soil does not stick to the pods, facilitating easier harvesting. Bright and clean pods are considered more valuable than dusty or pale ones. However, if the soil is excessively dry with a crusted surface, pod losses may increase significantly**.**

Harvesting methods range from fully manual to fully mechanized systems. The main harvest stages include: uprooting, drying, and separation, which can be performed using various combinations of hand tools and machinery.

9.2. Uprooting

Manual Uprooting

In loose and soft soils, peanut plants can be pulled out by hand with their pods. Tools such as hoes may assist during the process. Uprooted plants are shaken to remove soil and small debris, collected in small piles, and left to wilt. Manual harvesting is especially common for upright-growing peanut varieties.

9.3. Plow Uprooting

A plow passed between rows uproots peanut plants with their pods, similar to potato harvesting, and lays them on their side. However, plant collection and piling are still labor-intensive.

9.4. Mechanical Uprooting

Advanced peanut harvesters typically consist of three main components**:** digging blades, elevators, and windrow-forming wings. In two-row machines, V-shaped blades loosen the soil and cut the main root. Fingers behind the blades prevent pods from falling back into the soil. The blade depth is adjustable via the tractor’s hydraulic system. Uprooted plants are transported by elevators to the windrow-forming section, where soil is removed, and the cleaned plants are arranged in windrows on the field.

9.5. Drying

Freshly harvested peanuts usually contain 35–40% moisture, which should be reduced **to** 7–9% for safe storage. During drying, aerial plant parts also dry and become easier to separate from pods. Direct sun exposure can darken pods, reduce market value, and cause wrinkling. Rain or dew increases the risk of mold. Low-moisture pods have brittle shells; high-moisture pods are harder to shell.

9.6. Drying Methods

9.6.1. Pile Drying

Conical peanut piles are formed on soil or a supporting structure. Properly constructed piles protect pods from sun and rain. Piles are typically made manually.

9.6.2. Windrow Drying

Windrow drying is similar to hay drying and is suitable for mechanized threshing. Frequent turning of the windrows is necessary. This method reduces labor but provides limited protection from weather.

9.6.3. Artificial Drying

To overcome weather-related risks, hot-air dryers can be used. Although costly, artificial drying improves pod yield and quality.

9.6.4. Post-Harvest Drying

After threshing, peanuts typically have ~25% moisture, which must be reduced to 7–9% for storage. Layers approximately 15 cm thick are spread in the open air for 2–3 days and turned several times. Artificial dryers can accelerate this process.

Small family farms in Turkey usually harvest by hand. Male workers pull the plants, while women and children separate the shells from the stems. The sun drying takes several days, but early autumn rains in regions such as the Aegean can cause significant problems.

9.6.5. Green Harvest

Machines have been developed that uproot, collect, and thresh pistachios at the same time. These widely used machines are standard in regions with high labor costs or unfavorable climatic conditions, thereby improving product quality. Approximately 96% of the shells are threshed, with less than 5% loss, but soil contamination may be higher. The separated stems can be used as silage or dry feed if they do not contain pesticide residues. The main advantages of green harvesting are controlled drying and reduced mold contamination, while the main disadvantage is the additional drying cost.

Post-harvest husk residues may remain in the soil depending on the harvest time, method, soil compaction, moisture, and pest/disease conditions. Raking the soil brings the husks to the surface, making collection easier.

9.7. Peanut Yield

Dry fodder yield is 3000–6000 kg/ha, and pod yield, in-shell, depends on variety and cultivation methods, is 500–5000 kg/ha. The harvest and threshing residues of peanuts are used as excellent animal feed.

9.8. Chemical Composition and Nutritional Value

Pods comprise approximately 70–80% kernel and 20–30% shell. Shells are easily separable from kernels. Seeds comprise two cotyledons and an embryo, with red-brown, purple, or white testa. Seed structure: 72% cotyledon, 4.1% shell, 1.3% embryo. Seeds contain nearly equal proportions of lipids and non-

lipid matter. Protein content: ~29%, oil content: ~48–50%, varying with variety and seed quality.

Most lipids are in the cotyledons; only a small fraction is in the embryo or seed coat.

9.9. Quality Characteristics

Good quality peanuts should be fully mature, uniform in size, and have a low percentage of shriveled kernels. Peanuts should have a pleasant natural aroma and a tender texture. Early harvesting and rapid drying at temperatures above 49°C make blanching difficult and can result in a hard, flavorless kernel.

Each 100 grams of peanuts contains an average of 567 kcal of energy, which shows that peanuts are rich in nutrients. In addition, 100 grams contain 25.8 g of protein, 49.24 g of fat, and 16.13 g of carbohydrates. When fatty acids break down, the fat content contains 6.279 g of saturated fat, 24.426 g of monounsaturated fat, and 15.558 g of polyunsaturated fatty acids. In addition, peanuts are rich in minerals, containing 705 mg of potassium, 376 mg of phosphorus, 168 mg of magnesium, 92 mg of calcium, and 18 mg of sodium. Essential trace elements such as iron (4.58 mg), zinc (3.27 mg), copper (1.144 mg), and selenium (7.2 µg) are also present. Finally, the vitamin profile is also quite strong, containing 12.066 mg of niacin, 0.64 mg of thiamine, 0.348 mg of vitamin B6, 0.135 mg of riboflavin, 240 µg of folate, and 8.33 mg of vitamin E. Like all plant-based foods, peanuts do not contain cholesterol.

9.10. Minerals

Peanuts contain 3% ash, and the ash content in the hull is 4%.

9.11. Aflatoxins in peanuts

9.11.1. What is aflatoxin?

Aflatoxin is a naturally occurring toxic and carcinogenic substance produced by certain fungi in peanuts. It is known that a dose of 140 mg of aflatoxin can be fatal to an average-sized person. Aflatoxin also causes cancer by producing tumors in the liver. Out of 173 field and storage fungi studied, it was found that Aspergillus flavus and, to a lesser extent, Aspergillus parasiticus produce aflatoxins. Some characteristics of these fungi are as follows:

Fungi are tropical and thrive in relative humidity of 85-95% and temperatures of 25-30°C. They enter the peanut through the fruit shell and can progress to the testa and cotyledons. Low temperatures and humidity inhibit fungal growth.

9.11.2. Pre-harvest contamination

Although peanut fruits grow underground, they are quite resistant to the disease-causing effects of two fungi. For fungi to enter the fruits, there must be scratches, cracks, or fissures on their surface. These two main events observed before harvest create entry points for such fungi. Drought stress and soil pests severe drought during the final vegetation period 1-1.5 months before harvest facilitates Aspergillus entry. Irrigation during the second half of the vegetation period significantly reduces fungal attack in most cases. The second factor facilitating fungal entry is soil-borne pests. Fungal entry is facilitated through the damage caused by these pests, such as chewing and boring. In particular, insect activity is much higher in dry soils, and insufficient soil moisture leads to the failure of insecticide control. Thus, irrigation also facilitates chemical control.

9.11.3. Contamination during and after harvest

Contamination was higher during the drying and pre-storage period than during and after harvest. Thus, it was determined that aflatoxin formation occurs most frequently during the drying and pre-storage period. Considering that the samples were taken immediately after harvest, it is thought that aflatoxin contamination will continue under storage conditions and, as a result, aflatoxin contamination may increase. In addition, it has been concluded that the high moisture content of peanuts before storage may create a suitable environment for fungal growth and toxin production when stored under inappropriate conditions.

However, leaks, condensation, uneven drying, foreign matter, and high insect activity seen in unsuitable storage conditions rapidly increase the moisture content of seeds and fruits and promote the growth of Aspergillus. If insecticides are to be used in storage, gas-based insecticides should be preferred over liquid insecticides to prevent an increase in the moisture content of the environment.

9.11.4. Methods of combating aflatoxin

No fungicide has been found that prevents aflatoxin-producing molds from infecting plants during vegetation. Therefore, a series of more protective measures must be taken to combat aflatoxin.

9.11.5. Use of resistant varieties

The most effective method is undoubtedly the use of fungicide-resistant varieties. Research has shown that many varieties exhibit resistance to various fungi. However, this resistance disappears under intense stress conditions. Therefore, the use of resistant varieties is not currently considered very promising.

9.11.6. Measures to prevent fungal infection and growth

1. Crop rotation with other plants should be practiced.
2. Effective control of nematodes, weeds, diseases, and pests is important.
3. Cultural methods that promote rapid growth and healthy plant and bean production should be applied to prevent stress conditions.
4. Neither overly ripe nor underripe beans should be harvested.
5. Physical damage to the fruit and seeds should be avoided during harvesting.
6. Peanuts should be dried to 20% moisture content in the field, then threshed and artificially dried until the moisture content reaches 8%.
7. Factors that promote fungal growth should be avoided during transportation.
8. The fruit and seeds should be stored at a maximum moisture content of 10%, relative humidity of 70%, and low temperature conditions.
9. Insecticides should be used to prevent storage damage.

10. BREEDING

Breeding Objectives

Some researchers have evaluated peanut breeding objectives under the following headings.

10.1. High yield and suitability for mechanical harvesting

1. Shifting the balance between generative and vegetative development toward generative development is essential.
2. Increasing the number of seeds per fruit.
3. High kernel ratio and seed size
4. Resistance to drought and salinity
5. Strong seed dormancy in case of delayed harvest due to various reasons
6. Breeding of early and high-yielding varieties
7. Resistance to early frost
8. Obtaining varieties suitable for mechanical harvesting, tighter fruit attachment to the plant, and fruit skin resistant to mechanical harvesting
9. Resistance to nematodes and pests
10. Breeding of varieties resistant to pesticides and highly responsive to fertilizer applications, irrigation, and artificial drying
11. Resistance to diseases, especially to aflatoxin-producing Aspergillus species

10.2. High quality

1. High protein and increasing the amino acid ratio, especially methionine, in protein.
2. Developing varieties with high oil content and high oleic acid content.
3. Uniform grain size and color.
4. Better taste to meet consumer demands.
5. Durability for transportation and storage.

10.3. Hybridization Technique in Peanut

Flowers expected to open the next day on the parent plant (with petals swollen to open) are emasculated. However, all

previously opened and later flowers are removed. Those to be hybridized are left on the plant. The petals are separated, and the stamens are removed from the base. This is done using forceps. Emasculation should be performed in the evening on flowers that will open the next day. Delaying emasculation can lead to the risk of anthers cracking and self-pollination. Emasculation should be performed before the pollen grains become fertile. Pollination is performed by bringing pollen grains from the desired male parent onto the stigma of the emasculated parent. A soft-bristle brush is used for this process.

10.4. Breeding Methods

10.4.1. Introduction

This involves collecting peanut varieties of domestic and foreign origin and using them in a specific region, either for production or as parent plants in breeding efforts.

Introduction material can carry various diseases and pests. Therefore, this material is grown in observation gardens in the first year. Diseases and pests are controlled. It is grown again the following year and controlled. It is then tested with standard varieties grown in the region. Varieties superior to the standard array are included in adaptation trials, and varieties well adapted to the area are selected and propagated.

10.4.2. Selection

Mass Selection

Mass selection is one of the oldest and simplest breeding methods. As the name suggests, plants are selected collectively, not individually. All plants believed to possess desired phenotypic (physical appearance) traits are selected within a plant population. For example, the tallest, largest-seeded, or earliest-maturing plants are chosen collectively. The seeds from these selected plants are harvested and mixed without being separated.

This mixed bulk of seeds is then planted to form the next generation. This cycle is repeated until the desired traits become widespread within the population.

Mass selection is particularly effective for producing seeds and maintaining the purity of an existing variety. This method increases the frequency of dominant traits in a genetically heterogeneous (genetically diverse) population. It focuses on improving the general characteristics of a population rather than the individual genotype.

Progeny controlled single selection

This method is a more sensitive technique than mass selection. Plants are selected individually, not in groups. Genetic values are determined by evaluating their fertilization. Colors with targeted symbols are selected individually from the population. Each selected starter seed is harvested, threshed separately, and planted the following year for the next breeding phase.

In this way, its first offspring are grown in a separate row or separation. During this phase, the performance of its offspring is assessed uniformly. Even if a plant appears good, the breeding program is discontinued if its offspring exhibit poor characteristics. This control process continues until pure lines with the desired characteristics are obtained.

10.4.3. Combination Breeding

Pedigree Method

The pedigree selection method is based on selecting individual plants from the opening generations and creating pure lines. The technique is applied yearly as follows:

Year 1: Parents are crossed.

Year 2: 10-25 F1 plants and their seeds from the crosses are sown in bulk. From these, 1000-2000 individual plants are selected.

Year 3: The seeds of each plant selected in the second year are sown in single rows. This will grow 1000-2000 F2 rows. From these, 300-500 plants or progeny rows are selected.

Year 4: 300-500 plants selected from the F2 are planted in rows to grow F3 progeny. 50-100 rows that do not show opening, and individual plants within the row are selected.

Years 5-8: The best plants from the selected rows are grown into families in the fourth year—the best families and, within these, the best rows are selected. After the fifth year, individual plant selection is discontinued. 25-50 suitable rows (lines) are selected.

Year 9: Selected lines are taken into preliminary yield trials.

Years 10-13: Lines that perform well in the preliminary yield trials are taken into the yield trials with standard varieties. Superior lines that surpass the standard variety are selected for production.

10.4.4. Bulk Method

This method is a long process, typically lasting 15 years, with a specific purpose for each year. Here is a more detailed explanation of the stages.

Year 1: The first step of the breeding program is to hybridize two different parent plants with desired traits. This forms the basis of genetic diversity.

Year 2: F_1 Generation. The seeds from the cross are planted. These plants form the F_1 (first hybrid) generation. They

generally carry a combination of traits from both parents. At this stage, 10-25 plants are grown.

Year 3: F_2 Generation. The seeds produced by the self-pollination of the F_1 plants are planted. This F_2 generation is the stage with the most genetic diversity. The seeds from all plants are harvested and mixed in bulk. The goal is to preserve all genetic variation.

Years 4-6: F_3-F_5 Generations. The mixed seeds from the previous year are grown in bulk. No selection is made during this stage. The aim is to allow the population to become genetically more uniform through natural selection. Important: As stated, selection begins in the F_5 or F_6 generation. This allows time for the population to mature in terms of desired traits. The first individual selection can begin in F_5.

Year 7: Individual Plant Selection. In the F_5 or F_6 generation, the best 800-1000 individual plants with desired traits (e.g., high yield, disease resistance, good seed quality) are selected.

Year 8: Row Trials. The seeds from each individual plant selected in the previous year are planted in separate rows. This allows for identifying the best-performing lines from among 100-300 rows. The rows' growth performance, appearance, and other characteristics are evaluated.

Year 9: Small Plot Trials. The selected superior lines are planted in larger areas (small plots). At this stage, the performance of each line is examined in more detail, and the best ones are identified.

Years 10-14: Yield Trials. The selected lines are tested in different locations and under various conditions during this long process. First, micro yield trials are conducted with small lines in small plots, and then their performance is compared in macro

yield trials in larger areas and regional trials. This process examines yield statistics and other agronomic traits in detail.

Year 15: Final Selection and Seed Production. After all trials, 1 or 2 lines that have the most superior traits are selected. The seeds from these lines are multiplied for commercial production and made available for farmers.

10.4.5. Backcross Method

The backcross method is a breeding technique that transfers a single desired trait (from a donor parent) into an existing and well-adapted variety (the recurrent parent). The process is based on repeated backcrossing to eliminate undesirable genes and fix the desired gene.

In the first step, a recurrent parent, which is well-adapted to the region and has all the desired genetic characteristics except for the one being sought, is crossed with a donor parent that carries only the single desired trait (e.g., resistance to a specific disease).

Recurrent Parent (A) x Donor Parent (B) -> F_1

The resulting F_1 generation inherits 50% of its genes from the recurrent parent and 50% from the donor parent. The F_1 generation plants are crossed back to the recurrent parent. This main step gives the method its name, "backcrossing." This process is performed to reduce the undesirable genes from the donor parent.

F_1 x Recurrent Parent (A) -> BC_1 (First Backcross Progeny)

At this stage, the genetic makeup of the resulting BC_1 plants is approximately 75% from the recurrent parent and 25% from the donor parent. Plants carrying the desired trait from the donor are selected at this stage.

This process is repeated until the desired trait is genetically fixed. In each backcross, the previous generation is again crossed with the recurrent parent.

BC_1 x Recurrent Parent (A) -> BC_2

BC_2 x Recurrent Parent (A) -> BC_3

And so on. With each backcross, the genetic contribution from the donor parent is halved. In BC_3, the donor genetic contribution is reduced to 6.25%, and in BC_4, it is 3.125%.

The ultimate aim is to create a new variety that is a nearly identical copy of the recurrent parent but with one extra beneficial trait.

10.5. Mutation Breeding Method

In plant breeding, attempts are made to create genotypic changes to obtain new combinations. Sometimes, sudden and heritable changes occur in the plant due to changes in the structure of chromosomes and genes. This is called a mutation, and the new types resulting from mutation are called mutants.

Seeds exposed to mutagens are planted, and these plants form the M_1 generation. Mutations occur in this generation. However, in most cases, they are not immediately noticeable in the recessive phenotype. Therefore, M_1 flowers generally appear normal. The M_1 generation is allowed to self-pollinate, and the plants are planted. The resulting M_2 generation is the stage with the highest probability of the recessive traits emerging in the phenotype. However, new and distinct mutant types gradually begin to appear. These mutant flowers may be different in color, taller, more robust, or have a different leaf shape than the original parent.

Single selection is conducted among the mutant types emerging in the M_2 generation. Plants and plants that comply with breeding regulations are harvested. These seeds are then

examined in subsequent generations (M_3, M_4, etc.) to determine whether they are redundant, stable, and retain other desirable traits. Mutant lines chosen to be superior are subjected to field trials, registered as new varieties, and produced.

REFERENCES

Anonim. (2023). *Global Groundnuts Production Share by Country*. https://www.reportlinker.com/dataset/54d18286633a416ea5f418b8a09dbcff419b6b45

Anonim. (2024b). *Yer fıstığı türleri ve özellikleri*. https://www.fistik.gen.tr/yer-fistigi.html

Anonim. (2025). *Tescilli çeşit listesi*. https://www.tarimorman.gov.tr/BUGEM/TTSM/Sayfalar/Detay.aspx?SayfaId=85

Anonim. (2025). *bku veri tabanı*. https://bku.tarimorman.gov.tr/Zararli/Details/1146

Anonim. (2025a, Ağustos 7). *Top Peanuts Exports & Imports by Country Plus Average Prices*. https://www.worldstopexports.com/top-peanuts-exports-imports-by-country-plus-average-prices/

Anonim. (2025b, Ağustos 7). *Major Oilseeds: World Supply and Distribution*. https://www.fas.usda.gov/sites/default/files/2025-07/oilseeds.pdf

Anonim. (2025c, Ağustos 7). *World peanut production by country*. https://www.atlasbig.com/countries-peanut-production#google_vignette

Arıoğlu, H. (1992). *Yağ Bitkileri (Soya ve Yerfıstığı)*. Çukurova Üniversitesi Ziraat Fakültesi Ders Kitabı No: 35.

Arıoğlu, H. (1999). *Yağ Bitkileri Yetiştirme ve Islahı*. Çukurova Üniversitesi Ziraat Fakültesi Yayın No: 220.

İlisulu, K. (1970). *Yağ Bitkileri ve Islahı*. Çağlayan Kitabevi.

Kadiroğlu, A. (2023). *Yerfıstığı Yetiştiriciliği Ders Notları*. Antalya Tarım ve Orman Müdürlüğü. https://antalya.tarimorman.gov.tr/Belgeler/Yerf%C4%B1st%C4%B1%C4%9F%C4%B1%20Yeti%C5%9Ftiricili%C4%9Fi%20Ders%20Notlar%C4%B1.pdf

Kadiroğlu, A. (2025). *Yerfıstığı Yetiştiriciliği*. Batı Akdeniz Tarımsal Araştırma Enstitüsü Müdürlüğü. https://arastirma.tarimorman.gov.tr/batem/Belgeler/Kutuphane/Teknik%20Bilgiler/yerfistigi%20yetistiriciligi.pdf

Kemaloğlu, İ. & Özertan, G. (2024a, Ekim). *Tarımsal ürünler pazar değerlendirme raporu*. Hububat Tedarikçileri Derneği. https://www.hububder.org.tr/wp-content/uploads/2024/12/tarimsal-urunler-pazar-degerlendirme-raporu-ekim2024.pdf

Kolsarıcı, Ö. (2011). *Tarla Bitkileri*. Ankara Üniversitesi Ziraat Fakültesi Yayınları, Yayın No: 1588, Ders Kitabı: 540.

Lavkor, İ., & Biçici, M. (2015). Osmaniye'de Yetiştirilen Yerfıstıklarında Hasat, Hasat Sonrası, Kurutma ve Depo Öncesi Dönemlerinde Aflatoksin Oluşumu. *Journal of Agricultural Sciences, 21*(3), 394–405.

Özalp, B. B. & Kürklü, N. S. (2020). Fonksiyonel Bir Gıda: Yer Fıstığı ve Sağlığa Yararları. *Akademik Gıda, 18*(3), 323–330. https://dergipark.org.tr/tr/download/article-file/1370252

Şimşek, T., Kalkancı, N., Büyük, G., Mercan, Ş., & Kösetürkmen, S. (2024). Yerfıstığı (Arachis hypogaea L.) yetiştiriciliği yapılan toprakların verimlilik durumunun belirlenmesi: Osmaniye örneği. *Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi, 29*(3), 862-872.

Turan, Z. M. & Göksoy, A. T. (1998). *Yağ Bitkileri*. Uludağ Üniversitesi Ziraat Fakültesi Ders Notları No: 80.

Weiss, E. A. (1983). *Oilseed Crops*. Longman.

Yürür, N., Açıkgöz, E., Azkan, N., Çelik, N., & Göksoy, A. T. (1994). *Tarla Bitkileri*. Uludağ Üniversitesi Ziraat Fakültesi, Ders Notları No: 4.

A STUDY ON THE DETERMINATION OF PHYTOCHEMICAL PROPERTIES AND USAGE AREAS OF SOME *HYPERICUM* SPECIES DISTRIBUTED IN IDA MOUNTAINS

Cenk PAŞA[1]

Turgut KILIÇ[2]

1. INTRODUCTION

Medicinal plants serve as the primary source of therapy for approximately 60 % of the global population and nearly 80 % of people in developing countries. A total of 121 active compounds and 25 % of approved medications worldwide are derived from plants (DellaPenna, 2001). Plants are the source of 28 out of the 252 medications (11.1 %) that the World Health Organization (WHO) has recognized as basic and essential (Hoareau and Da Silva, 1999). A World Health Organization (WHO) research based on 91 nation's pharmacopoeias and other publications on medicinal plants estimates that there are over 20,000 different kinds of medicinal plants used for therapy (Kalaycıoğlu and Öner, 1994). These can be collected from nature or from cultivated medicinal plants (Hamburger and Hosstettmann, 1991). Despite having about 9,000 different plant species, Turkey does not make full use of them. Approximately 1,000 plants are thought to be utilized in Turkish traditional medicine (Başer, 1992). Since ancient times, *Hypericum* species

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have been utilized in traditional medicine to cure a variety of illnesses. Even though the use of these plants has declined with the growth of the synthetic drug industry, research on medicinal plants and their active compounds has increased due to the harmful side effects of synthetic pharmaceuticals and the complex therapeutic effects of herbal medicines. However, these plants must be cultivated because they are hard to gather from nature and the survival of their species is in jeopardy. In addition to traditional culture, they are now commonly cultivated through tissue cultures in many wealthy nations (Karakaş, 2010).

Hypericum means "ghost, evil spirit repellent" in Greek, and the genus has been utilized extensively in medicine from ancient times. It was claimed that this plant had protecting properties and could drive out evil and evil thoughts. Additionally, *Hypericum* was linked to one of the Christian saints, St. John. When *Hypericum* began to flower in June 21–24, it was said that St. John (Hz. Yahya) was born. It was thought that St. John was murdered in August when red spots appeared on *Hypericum* leaves, causing the plant to bleed. The plant known as "St. John's Wort" is harvested on June 24th, which is "St. John's Day" (Baytop, 1984). Its leafy, blooming, and fruity branches and roots are employed in traditional medicine (Kumper, 1989; Kako and Saleem, 1993).

According to Nürk et al. (2013), there are roughly 500 species in the genus *Hypericum* L. (Hypericaceae) worldwide. Nearly every continent has it, particularly those with moderate climates (Crockett and Robson, 2011). The genus *Hypericum* contains 107 species, 48 of which are unique to Turkey, according to the Flora of Turkey (Başköşe and Savran, 2018). According to Baytop (1999), the public refers to *Hypericum* species as "kantaron," "kılıçotu," "kanotu," "kuzukıran," and "binbirdelik otu." This study set out to identify the phytochemical characteristics and areas of use of the species *Hypericum*

perforatum, *Hypericum montbretii*, and *Hypericum aucheri* that are found in the Kaz Mountains.

2. HERBAL PROPERTIES

It is crucial to consider the form, appearance, and distribution of the glands while classifying *Hypericum* species near organs like sepals, petals, and leaves, the glands are referred to as "marginal glands" if they are near the edges; "intermarginal glands" if they are farther inside the edge; and "superficial glands" if they are in the center of the organ, far from the edge. We refer to the glands in the capsule wall and ovary as oil glands. "Saccas" refers to the shorter, more enlarged glands (Robson, 1967; Davis 1967; Karakaş, 2010).

2.1. Herbal Properties of *Hypericum perforatum* L. Species

The plant *Hypericum perforatum* L. is an herbaceous perennial. The plant's basic chromosome number is x=8, and it belongs to the Hyperiaceae family (Robson and Adams, 1968). Although there are diploid and hexaploid varieties of *H. perforatum*, it is typically a tetraploid (2n=4x=32) plant. Originating in arid parts of North America and Europe, the plant most likely emerged in ancient times due to chromosome duplications and spontaneous hybridization between *H. maculatum* Crantz and *H. attenuatum* L. (Deltito and Bayer, 1998). The plant grows between 30 and 100 cm tall, with elliptic, nearly stemless leaves that are 10 to 35 mm long. The sebaceous glands are clearly apparent as a large number of brilliant spots when the leaves are held up to the light.

It is known as the “binbir delik” plant because of this characteristic. May and July is when it flowers. The golden yellow, five-part petals of the flower are encircled by glandular

hairs with black spots. There are many stamens, which are arranged in three bundles. It grows at altitudes of 0–2500 m on field regions, meadows, and roadside (Davis, 1967). Typically, rhizomes and seeds are used to grow *H. perforatum* (Matzk et al., 2001). The production of *H. perforatum* through field cultivation in various ecologies is hindered by the dormancy of its seeds (Çırak et al., 2004a, 2004b), the challenge of planting with vegetative parts, and the high sensitivity of the plant to anthracnose (*Colletotrichum gloeosporioides*) disease (Bourgaud et al., 2001).

2.2. Herbal Properties of *Hypericum montbretii* Spach. Species

A perennial herbaceous plant is *Hypericum montbretii* Spach. The primary root, which has several branches, forms the root portion. April to July is when it blooms. It grows between 200 and 700 meters above sea level in moist, shaded areas amidst rocks. The height of the plant is 15–60 cm. The leaves range in size from 15 to 55 mm and are either triangular or ovate-lanceolate. The leaves can occasionally have black stains on their surface. The sepals are elliptic and lanceolate. The petals are 8–14 mm in size and may have black spots or not. According to Davis (1967), the fruit capsule is ovoid-pyramidal, 7–10 mm in size, and has longitudinal stripes on its surface.

2.3. Herbal Properties of *H. aucheri* Jaub. & Spach. Species

H. aucheri Jaub. & Spach. is an herbaceous perennial. The stem is 9–35 cm long, either upright or erect, and occasionally branches and roots at the base. The oblong to lanceolate or linear leaves, which range in length from 4 to 24 mm, with translucent dots and less noticeable reticulate venation. Sepals can be long denticulated or linear to lanceolate to ovate-lanceolate, with one or two black glands on the surface or none at all. They are also

sharp, almost irregularly black-glanded, and fringed. The 7–12 mm long petals typically lack black glands on their surface. 3–4 mm is the length of the capsules (Davis, 1967).

3. PHYTOCHEMICAL CHARACTERISTICS AND APPLICATIONS

Hypericin and hyperforin are found in species of *Hypericum* (Barnes et al., 2001). Hypericin is chemotaxonomically significant for intrageneric classification and was only detected in *Hypericum* species (Kitanov, 2001). According to Medina et al., (2006), hyperforin is a prenylated phloroglucinol derivative made up of lipophilic isoprene chains attached to a phloroglucinol skeleton. According to Guedes and Eriksson (2005), hypericin and pseudohypericin are used for their antibacterial, antipsoriatic, antidepressant, and antitumoral properties. Hyperforin contains antitumoral, depressive, anti-inflammatory, and antiangiogenic properties (Dona et al., 2004; Roz and Rehavi, 2004).

3.1. Phytochemical Properties and Usage Areas of Hypericum perforatum L. Species

According to an analysis of *Hypericum perforatum* L. species' chemical makeup, there are seven distinct component groups (Mutlubaş and Özdemir, 2020). Typically found in dark-colored glands in the aboveground sections, naphthodianthrones (psodohypericin, protohypericin and hypericin) exhibit pharmacological actions that are antiviral, photodynamic, and antitumor. The root portions typically include xanthones (kielkorin, mangiferin), which have pharmacological actions that are anti-inflammatory, antibacterial, and antioxidant. Flowers and leaves include amino acids, such as cysteine, which are involved in a number of biological processes. Colorless-transparent glands contain unstable chemicals called phenolglucinols, such as

hyperforin and achiperforin, which have pharmacological actions that are antidepressant, antibacterial, anti-inflammatory, and cytotoxic. The aboveground portions contain proanthocyanidins (catechin, epicatechin), which often have astringent and antioxidant pharmacological properties. The flowers and aboveground sections contain biflavonoids, which have antioxidant and antiphlogistic properties (biapigenin, amentoflavone). The plant's flowers and leaves contain essential oils, which have pharmacological properties that are both antioxidant and antibacterial (Ersoy et al., 2020; Nürk and Blattner, 2010). Researchers found that the primary constituents of the essential oil were 2,6-dimethyl-heptane (6.25–36.07 %), β-pinene (18.32%), α-pinene (5.56-30.92%), δ-cadinene (0.0–2.58%), γ-cadinene (0.0-16.9%), and caryophyllene (15.26%), along with (E)-β-caryophyllene, germacrene D, β-elemene, eudesma-4,7-dien-1β-ol, thymol, 1,4-trans-1,7-trans-acorenone, decane, dodecane, ethyl cyclohexane, Components of 5-methyl nonane, 3-methyl nonane, 2,6-dimethyl-heptane, α-pinene, δ-cadinene, γ-cadinene, β-pinene, (E)-β-ocimene, 2-methyl decane, undecane, germacrene D, nonane, n-octane, dodecanol, germacrene D, β-caryophyllene, 2-methyl octane, bicyclogermacrene, (E)-β-ocimene, β-selinenol, elemol, bicyclogermacrene, tetradecane, and α-amorphene (Crockett, 2010; Paşa, 2013; Arpag et al., 2020).

According to historical accounts, it has been used as a wound healer since ancient times (Bridi et al., 2018), as a remedy for ailments like diabetes, stomach ulcers, cancer, liver diseases, stomach diseases, diarrhea, and bronchitis (Zhou et al., 2020), and by Native Americans as an antipyretic and cough remedy (Istikoqlou et al. 2010). In addition to treating kidney stones, jaundice, gout, and rheumatism (Grene, 1824), the decoction made from *H. perforatum* was used to clear the urinary system of sand and irritation (Hill, 1808). Additionally, this decoction

reduces intestinal parasites and has antipyretic properties. According to Griffith (1847), *H. perforatum* oil has diuretic properties and could be applied locally and internally to cure cancer and ulcers. Throughout the Roman Empire, *H. perforatum* oil was used to heal burns and sciatic symptoms, and its decoction was used to encourage menstruation and lessen women's menstrual cramps (Gunther, 1968). King (1876) documented the use of *H. perforatum* externally to heal physical injuries and internally in the late 1800s to treat hysteria, painful menstruation, diarrhea, jaundice, urinary aches, and neurological problems associated with depression. *H. perforatum* tincture was suggested by Felter and Lloyd (1898) for hysteria, physical shocks, concussions, puncture wounds, and spinal diseases. In his research, Duke (1985) collated the traditional usage for treating lymphomas, stomach cancer, uterine cancer, and ovarian polyps. According to the researcher, Russian traditional medicine used the plant to cure a wide range of illnesses, including bronchitis and asthma, diarrhea, dysentery, neurological disorders, depression, hysteria, chronic cold, rabies, hemorrhages, intestinal parasites, and urinary tract infections. According to Çırak and Kurt (2014), St. John's wort has been extensively researched in clinical and laboratory settings for the past 30 years and is currently being utilized extensively to treat depression.

3.2. Phytochemical Properties and Usage Areas of Hypericum montbretii Spach Species

Hypericin 1.27 mg/g, pseudohypericin 2.97 mg/g, hyperforin 6.64 mg/g, adiperforin 1.24 mg/g, (+)-Catechin 1.54 mg/g, (-)-epicatechin 4.35 mg/g, chlorogenic acid, neochlorogenic acid amentoflavone, hyperoside, isoquercitrin, quercitrin, quercetin, avicularin, and rutin were found in investigations on the plant's bioactive components (Çırak at al., 2007; Çırak et al., 2008).

α-pinene (19.0-25.7%), β-pinene (18.8%), sabinene (14.6%), undecane (4.8-8.0%), germacrene D (5.9%), carvacrol (22.0%), β-caryophyllene (5.7-7.1%), and δ-cadinene (4.9-5.8%) were identified as the primary constituents of the essential oil in *H. montbretii* species in the researchers' investigations (Erken et al., 2001; Paşa, 2013, Paşa et al., 2018).

A perennial plant, *Hypericum montbretii* Spach. thrives in Georgia, Syria, the Balkans, and northern Turkey in environments that are wet or shaded. In folk medicine, the plant is referred to as a "tea herb" and has been used to boil kidney stones, stomach issues, ulcers, and hemorrhoids (Altundağ and Öztürk, 2011). Additionally, its antidepressant, antioxidant, immunomodulatory, and eczema properties make it useful in medicine (Keskin and Alpınar, 2002; Demirkıran et al., 2009).

3.3. Phytochemical Properties and Usage Areas of *Hypericum aucheri* Jaub. & Spach Species

Distributed over Southeastern Bulgaria, Greece, Europe, and Northwestern Turkey, *Hypericum aucheri* is a perennial herbaceous flowering plant (Robson, 1967). Xanthones, flavonoids, biflavone, hydroxycinnamic acid, chlorogenic acid, pernyloxy chromanone derivatives (aucherine A-C), prenylated phloroglucinols, phenolic compounds, and mangiferin were found in the plant, according to phytochemical analyses (Kitanov et al., 1979; Kitanov, 1988).

Magniferin and a crystalline component were separated from the *H. aucheri* plant's alcohol extract. 1,3,6,7-Tetrahydroxyxanthone was the name given to this crystalline molecule (Kitanov et al., 1979). The compounds found in Magniferin have antiviralantibacterial and immunostimulatory properties. Magniferin does not exhibit mutagenic activity and possesses cardiostimulant, choleretic, and antihepatotoxic qualities additionally, in the 1950s, monoamine oxidase inhibitors

derived from the plant were employed as antidepressants to treat various neurological and psychiatric conditions (Bennett and Lee, 1989).

The *Hypericum aucheri* species was found to contain 69 essential oil components. Germacrene D 22.0%, τ-muurolene 6.9%, α-cadinene 6.8%, α-cadinol 6.2%, delta-cadinene 5.8%, gamma-amorphene 5.7%, tau-muurolol 5.3%, Valencene 5.1%, Gurjunene-gamma 4.9%, β-selinene 3.6%, α-humulene 3.3%, Caryophyllene 2.8%, 3-methyl nonane 2.6%, Limonene 2.6%, α-pinene 2.3%, and Aromadendrene 2.0% were identified as the essential oil's primary constituents (Paşa, 2013).

4. RESULTS

Researchers from various academic disciplines have shown considerable interest in the *Hypericum* genus. These plants have been the focus of extensive research for many years due to their complex taxonomy, chemical diversity, ethnobotanical applications, and global use in traditional medicine, and relevance in contemporary pharmacology. This study aims to identify the phytochemical properties and application areas of *Hypericum perforatum*, *Hypericum aucheri*, and *Hypericum montbretii* found in the Kaz Mountains. In terms of *Hypericum* species, our country is a leading region; however, these plants are often harvested from the wild without species differentiation. Uncontrolled collection has led to the decline of several endemic species in their natural habitats. Pharmacologically significant compounds in *Hypericum* species include hypericin and hyperforin, both recognized for their substantial therapeutic potential.

REFERENCES

Altundag, E., Ozturk, M., (2011). Ethnomedicinal studies on the plant resources of east Anatolia, Turkey. *Procedia-Social and Behavioral Sciences*, *19*, 756-777.

Arpag, O. F., Duran, N., Açikgül, F. C., Türkmen, M., (2020). Comparison of minimum inhibitory concentrations of *Hypericum perforatum* L. essential oils, 0.2 % chlorhexidine and 10% povidone-iodine over Aggregatibacter actinomycetemcomitans and Porphyromonas gingivalis. *Journal of Essential Oil Bearing Plants*, *23*(6), 1192-1205.

Barnes, J., Anderson, L. A., Phillipson, J. D., (2001). St John's wort (*Hypericum perforatum* L.): a review of its chemistry, pharmacology and clinical properties. *Journal of pharmacy and pharmacology*, *53*(5), 583-600.

Başer, K.H.C., (1992). Uçucu Yağların Dünya Ticareti, Anadolu Üniversitesi Tıbbi Bitkiler Araştırma Merkezi, Tıbbi Aromatik Bitkiler Bülteni. Sayı: 9. Eskişehir.

Başköse, İ., Savran, A., (2018). A new species from southern Anatolia (Dedegöl Mountain series-Çürük Mountain) in Turkey: *Hypericum bilgehan-bilgilii* (Hypericaceae). *Phytotaxa*, *374*(2), 110-118.,

Baytop, T., (1984). Türkiye'de Bitkiler ile Tedavi. İstanbul Üniversitesi Yayınları, No:3255, İstanbul.

Baytop, T., (1999). Türkiye'de Bitkiler ile Tedavi, Geçmişte ve Bugün. Nobel Tıp Kitabevleri, II. Baskı ISBN: 975-420-021- 1.İstanbul, 480s.

Bennett, G. J., Lee, H. H., (1989). Xanthones from guttiferae. *Phytochemistry*, *28*(4), 967-998.

Bridi, H., de Carvalho Meirelles, G., von Poser, G. L., (2018). Structural diversity and biological activities of phloroglucinol derivatives from *Hypericum* species. *Phytochemistry*, *155*, 203-232.

Crockett, S. L., (2010). Essential oil and volatile components of the genus *Hypericum* (Hypericaceae). *Natural product communications*, *5*(9), 1934578X1000500926.

Crockett, S.L., Robson, N.K.B., (2011). Taxonomy and Chemotaxonomy of the Genus *Hypericum*. Medicinal and Aromatic Plant Science and Biotechnology, 5, 1-13.

Çırak, C., Ayan, A., Kevseroğlu, K., (2004a). The Effects of Light and Some Presoaking Treatments on Germination Rate of St. John's Worth (*Hypericum perforatum* L.) Seeds. Pakistan Journal of Biological Sciences, 7: 182-186.

Çırak, C., Ayan, A., Kevseroğlu, K., Çalışkan, Ö., (2004b). Germination Rate of St. John's Worth (*Hypericum perforatum* L.) Seeds Exposed to Different Light Intensities and Illumination Periods. Journal of Biological Sciences, 4: 279-282.

Çırak, C., Radusiene, J., Janulis, V., Ivanauskas, L., (2007). Chemical constituents of some *Hypericum* species growing in Turkey. Journal of Plant Biology. 50(6) : 632-635.

Çırak, C., Radusiene, J., Janulis, V., Ivanauskas, L., (2008). Pseudohypericin and hyperforin in *Hypericum perforatum* from Northern of Turkey: variation among populations, plant parts and phenological stages. Journal of Integrative Plant Biology. 50 (5): 575–580.

Çırak, C., Kurt, D., (2014). Önemli Tıbbi Bitkiler Olarak *Hypericum* Türleri. Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi, 24(1), 38-52.

Davis, P.H., (1967). Flora of Turkey. Volume II. University of Edinburg. P.400, Edinburg.

DellaPenna, D., (2001). Plant metabolic engineering. Plant Physiology, 125: 160-163.

Deltito, J., Bayer, D., (1998). The scientific, quasi-scientific and popular literature on the use of St. John's worth in the treatment of depression. Journal of Affective Disorders, 51: 345-351.

Demirkiran, Ö., Mesaik, M.A., Beynek, H., Abbaskhan, A., Choudhary, M.I., (2009). Cellular reactive oxygen species inhibitory constituents of *Hypericum thasium* Griseb. Phytochemistry. 70: 244-249.

Dona, M., Dell'Aica, I., Pezzato, E., Sartor, L., Calabrese, F., Barbera, M. D., Garbisa, S., (2004). Hyperforin inhibits cancer invasion and metastasis. *Cancer research*, *64*(17), 6225-6232.

Duke, J.A., (1985). Handbook of Medicinal Herbs. CRC Press, Boca Raton, FL, pp. 242–243.

Erken, S., Malyer, H., Demirci, F., Demirci, B.,Baser, K. H. C., (2001). Chemical investigations on some Hypericum species growing in Turkey-I. *Chemistry of Natural Compounds*, *37*(5), 434-438.

Ersoy, E., Ozkan, E. E., Boga, M., Mat, A., (2020). Evaluation of in vitro biological activities of three *Hypericum* species (*H. calycinum*, *H. confertum* and *H. perforatum*) from Turkey. *South African Journal of Botany*, *130*, 141-147.

Greene, T., (1824). The Universal Herbal. Caxton Press, London.

Griffith, R.E., (1847). Medical Botany. Lea & Blanchard, Philadelphia.

Gunther, R.T., (1968). The Greek Herbal of Dioscorides. Hafner Publishing Company.

Hill, J., (1808). The Family Herbal. C. Brightly & T. Kinnersley, Bungay.

Felter, H.W., Lloyd, J.U., (1898). King's American Dispensatory, 18th ed., reprinted by Eclectic Medical Publications, Portland, OR.

Greene, T., (1824). The Universal Herbal. Caxton Press, London.

Griffith, R.E., (1847). Medical Botany. Lea & Blanchard, Philadelphia.

Guedes, R. C., Eriksson, L. A., (2005). Theoretical study of hypericin. *Journal of Photochemistry and Photobiology A: Chemistry*, *172*(3), 293-299.

Gunther, R.T., (1968). The Greek Herbal of Dioscorides. Hafner Publishing Company.

Hamburger, M., Hosstettman, K., (1991). Bioactivity in plants: the link between pyhtochemistry and medicine. Pyhtochemistry, 30: 3864-3874.

Hill, J., (1808). The Family Herbal. C. Brightly & T. Kinnersley, Bungay.

Hoareau, L., DaSilva, E. J., (1999). Medicinal plants: a re-emerging health aid. *Electronic Journal of biotechnology*, *2*(2), 3-4.

Istikoqlou C, Mavreas V, Geroulanos G., (2010). History and therapeutic properties of *Hypericum perforatum* from antiquity until today. Psychiatriki. 21: 332-8

Kako, M.D., Al-Sultan II Saleem, A.N., (1993). Studies of sheep Experimentally poisoned with *Hypericum* perforatum, Veterinary and Human Toxicology, 35(4): 298-300.

Kalaycıoğlu, A., Öner, C. (1994). Bazı Bitki Ekstraktlarının Antimutajenik Etkilerinin Ames-Salmonella test sistemi ile Araştırılması. Tr. J. Botany, 18, 117-122.

Karakaş, Ö., (2010). İn vitro şartlarda yetiştirilen *Hypericum triquetrifolium* Turra. (Guttiferae)'nın total hiperisin içeriğinin incelenmesi. Dicle Üniversitesi Fen Bilimleri Enstitüsü Biyoloji Ana Bilim Dalı, Yüksek Lisans Tezi.

Keskin, M., Alpınar, K., (2002). Kışlak (Yayladağı-Hatay) hakkında etnobotanik bir araştırma. Ot Sistematik Botanik Dergisi, 9 (2), 91-100.

King, K., (1876). The American Dispensatory, tenth ed. Wilstach, Baldwin & Company, Cincinnati.

Kitanov, G. M., Blinova, K. F., Akhtardzhiev, K., Rumenin, V. (1979). Flavonoids of *Hypericum aucheri*. *Chemistry of Natural Compounds*, *15*(6), 760-761.

Kitanov, G. M., (1988). Miquelianin and other polyphenols from *Hypericum hirsutum*. *Chemistry of Natural Compounds*, *24*(1), 119-120.

Kitanov, G. M., (2001). Hypericin and pseudohypericin in some *Hypericum* species. *Biochemical Systematics and Ecology*, *29*(2), 171-178.

Kumper, H., (1989). *Hypericum* poisoning in sheep, Tierarztl Prax, 17(3): 257-261.

Matzk, F., Meister, A., Brutovska, R., Schubert, I., (2001). Reconstruction of reproductive diversity in *Hypericum perforatum* L. opens novel strategies to manage apomixis. Plant Journal, 26: 275-282.

Medina, E., De Castro, A., Romero, C., Brenes, M., (2006). Comparison of the concentrations of phenolic compounds in olive oils and other plant oils: correlation with

antimicrobial activity. *Journal of agricultural and food chemistry*, *54*(14), 4954-4961.

Mutlubaş, H., Özdemir, Z. Ö., (2020). "*Hypericum perforatum*"un Geleneksel Tıp Alanındaki Uygulamaları. *Bütünleyici ve Anadolu Tıbbı Dergisi*, *1*(3), 10-22.

Nürk, N. M., Blattner, F. R., (2010). Cladistic analysis of morphological characters in *Hypericum* (Hypericaceae). *Taxon*, *59*(5), 1495-1507.

Nürk, N. M., Madriñán, S., Carine, M. A., Chase, M. W., Blattner, F. R., (2013). Molecular phylogenetics and morphological evolution of St. John's wort (Hypericum; Hypericaceae). *Molecular Phylogenetics and Evolution*, *66*(1), 1-16.

Paşa, C., (2013). Kaz Dağları'nda yayılış gösteren bazı *Hypericum* türlerinde uçucu yağ oranı ve bileşenlerinin diurnal, ontogenetik ve morfogenetik varyasyonunun belirlenmesi üzerine bir araştırma. *Fen Bilimleri Enst., Doktora Tezi*.

Paşa, C., Esendal, E., Kiliç, T., (2018). Ontogenetic and diurnal variations of essential oil content of *Hypericum montbretii* Spach, cultivated in Kazdağı (Edremit/Balıkesir), Turkey. *Agricultural Science & Technology (1313-8820)*, *10*(3).

Robson, N.K.B., (1967). Flora of Turkey and the East Aegean Islands. Edinburgh University Pres Edinburgh 1967, 340-355.

Robson, N.K.B., Adams, P., (1968). Chromosome number in *Hypericum* and related genera. Brittonia, 20: 95-106.

Roz, N., Rehavi, M., (2004). Hyperforin depletes synaptic vesicles content and induces compartmental redistribution

of nerve ending monoamines. *Life sciences*, *75*(23), 2841-2850.

Zhou, W., Zhang, Q., Sun, Y., Yang, L., Wang, Z., (2020). Genome-wide identification and characterization of R2R3-MYB family in *Hypericum perforatum* under diverse abiotic stresses. International Journal of Biological Macromolecules.

TÜRKİYE VE DÜNYADA

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