



## TRICHODERMA ZAMBURUĞIDAN OLINADIGAN IKKILAMCHI METABOLITLARNING UMUMIY TASNIFI

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**Annotatsiya:** *Trichoderma – dorivor ahamiyatga ega bo'lgan tarkibiy jihatdan xilma-xil, ikkilamchi metabolitlar xazinasi. Ushbu maqolada Trichoderma jinsining 220 yildan ortiq vaqt davomida to'plangan ma'lumotlar asosida shakllangan 382ta turi, hamda jins vakillarining tarixiy shakllanishi, biologik faolligini hamda noyob xususiyatlari haqida yoritdik.*

**Kalit so'zlar:** *Trichoderma, ikkilamchi metabolitlar, kimyoviy xilma-xillik, biologik faollik bioaktiv birikmalar.*

Zamburug'lar insoniyat tarixida dori vositalari va maxsulotlarini kashf etishda ajralmas rol o'ynaydi. Chunki ular muhim dorivor salohiyatga ega bo'lgan turli xil maxsus metabolitlarni sintez qilish uchun noyob qobiliyatga ega. Shu sababli yillar davomida ushbu zamburug' ustida juda ko'plab olimlar izlanishlar olib borishdi. Ushbu izlanishlar natijasida to'plangan barcha ma'lumotlar butun jinsning ulkan tarixini yaratdi. Trichoderma yaxshi o'rganilgan filamentli zamburug'lar bo'lib, tabiatda erkin holda uchraydi. Ular bioaktiv moddalar sifatida keng sotiladi.

Trichoderma – sordariomitsetlar sinfi, pezizomycotina bo'limi, Hypocreaceae oilasi, trichoderma jinsiga mansub tur hisoblanadi. Trichodermani birinchi bo'lib 1801-yilda nemis mikologi faoliyat yuritgan, mikologiya va taksonomiya fanlari rivojiga katta hissa qo'shgan olim Christian Hendrik Persoon (1761-1836) fanga kiritgan.

Trichoderma turlari ro'yxatida Trichoderma zamburug' jinsida qabul qilingan quyidagi 382 ta tur mavjud. Quyida ularni keltiramiz:

Trichoderma jinsi 1794-yil Kristian Xendrik Persoon tomonidan ilk bor tasvirlangan. Lekin ushbu jins taksonomiyasini hal qilish qiyinligicha qolmoqda. Uzoq vaqt davomida u faqat bitta turdan iborat deb hisoblangan. 1991-yilda Bissett Rifai tomonidan tasvirlangan agregat turlarga asoslanib, bu jinsni qisman 5 qismga ajratdi.

- Pachybasium (20 tur)
- Longibrachiatum (10 tur)
- Trichoderma (5 tur)
- Saturnisporum (2 tur)
- Gipokreanum (15 tur)



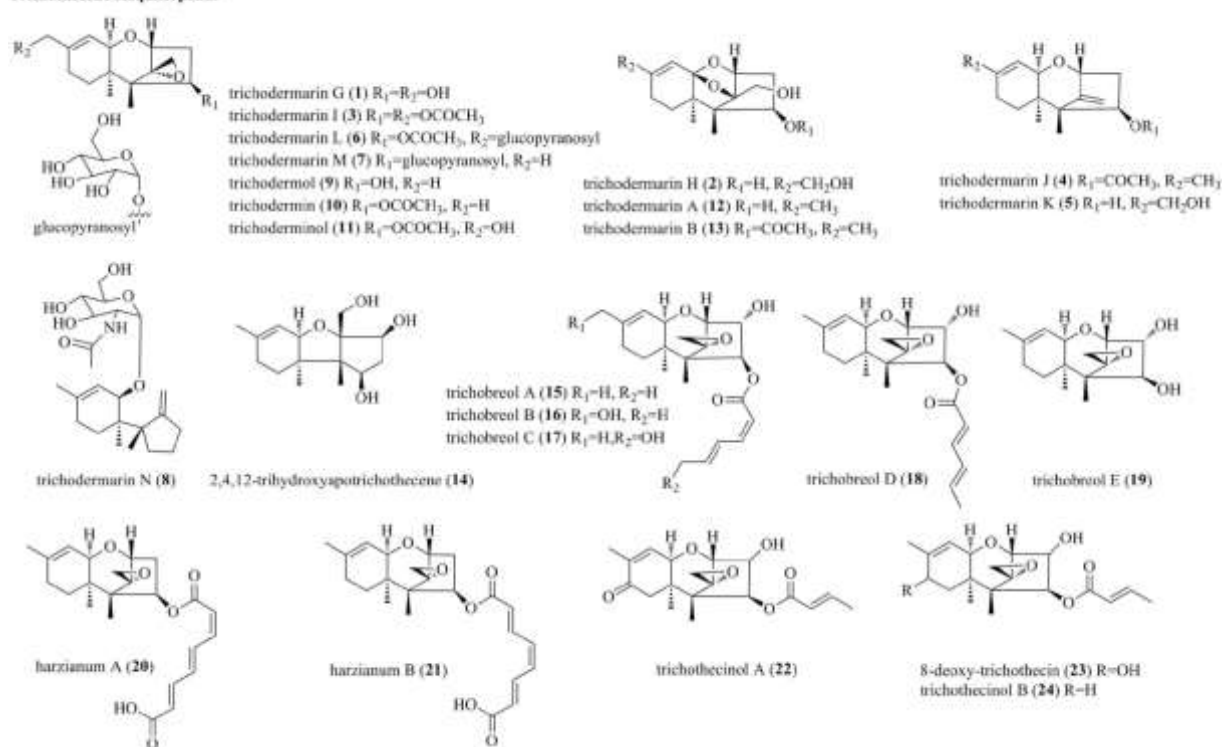
1995-yildan boshlab molekulyar markerlarning paydo bo'lishi bilan Bissettning sxemasi asosan tasdiqlandi, ammo *Saturnisporum Longibrachiatum* va *Hypocreanum monofiletik* bo'lib, uning ko'plab turlari *Trichoderma* bilan to'plangan.

Drujina va Kubicek 2005-yilda jinsning chegaralangan golomorf (tayyor zamburug') ekanligini tasdiqladi. Ular 88 turni aniqladilar. *Trichoderma*ning monotipik ekanligi haqidagi e'tiqod 1969-yilda 9 turni tan olgan Rifai ishiga qadar saqlanib qoldi. Bugungi kunga kelib *Trichoderma* jinsida 382 tur (2020-yil)mavjud. *Gipokrea* *Trichoderma*ning teleomorflari bo'lib, ularda anamorflar sifatida *Hypocrea* mavjud.

*Trichoderma*ning madaniy turlari 25-30 OC da (77-86 OF) da tez o'sadi, ammo *Trichoderma*ning ayrim turlari 45OC (113 OF) da o'sadi. Ammo koloniyalar dastlab makkajo'xori unidan olingan Dekstrozli muhitda shaffof bo'ladi yoki kartoshka dekstrozi kabi boyroq muhitda oqroq bo'ladi.

### 1. *Trichoderma* turlari tomonidan ishlab chiqarilgan trichothecene sesquiterpenes.(1-24)

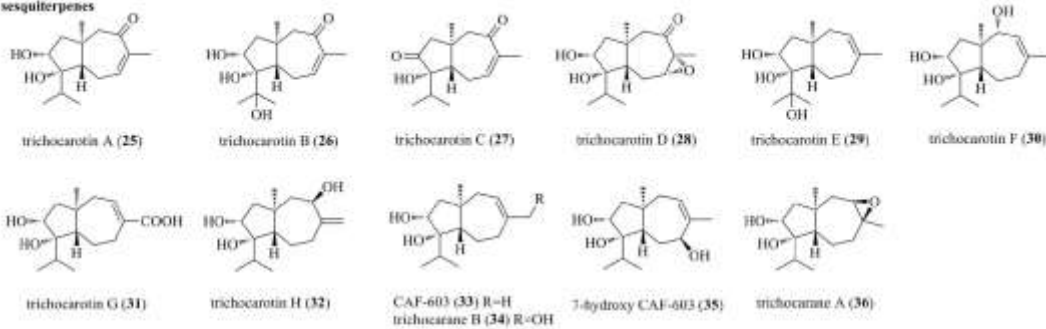
#### Trichothecene sesquiterpenes



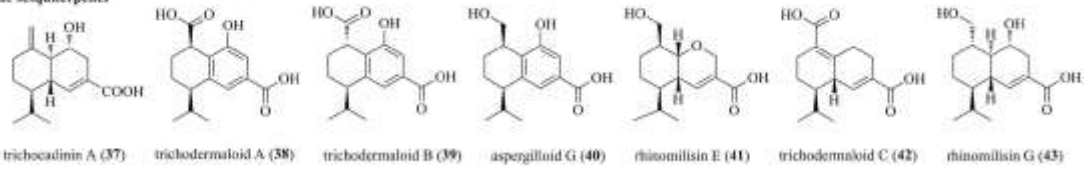
*Trichoderma* turlari tomonidan ishlab chiqarilgan karaton, kadinan va sikleneran sesquiterpenlar. (25-52)



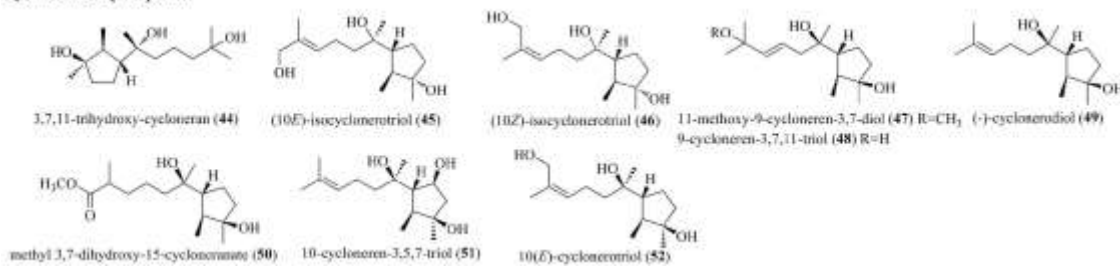
**Carotane sesquiterpenes**



**Cadinane sesquiterpenes**

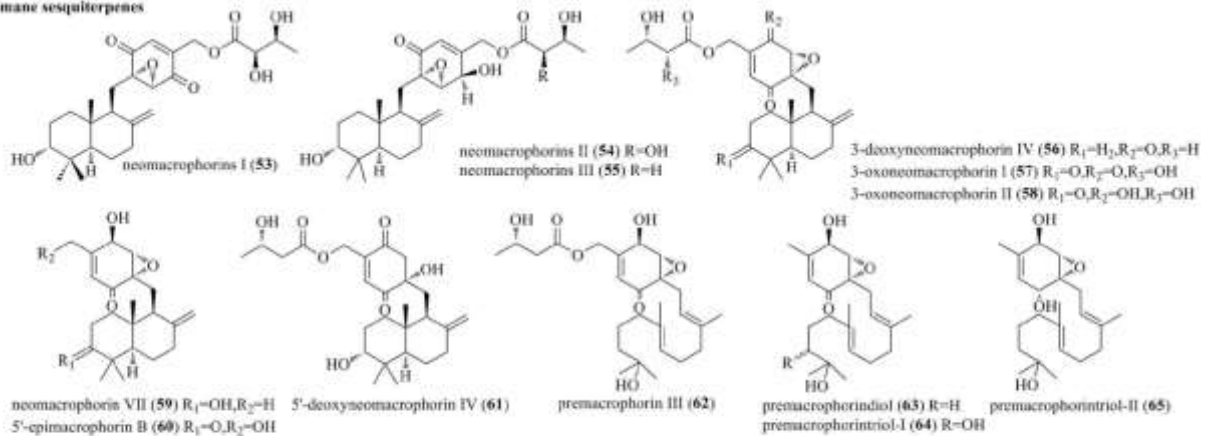


**Cyclonerane sesquiterpenes**

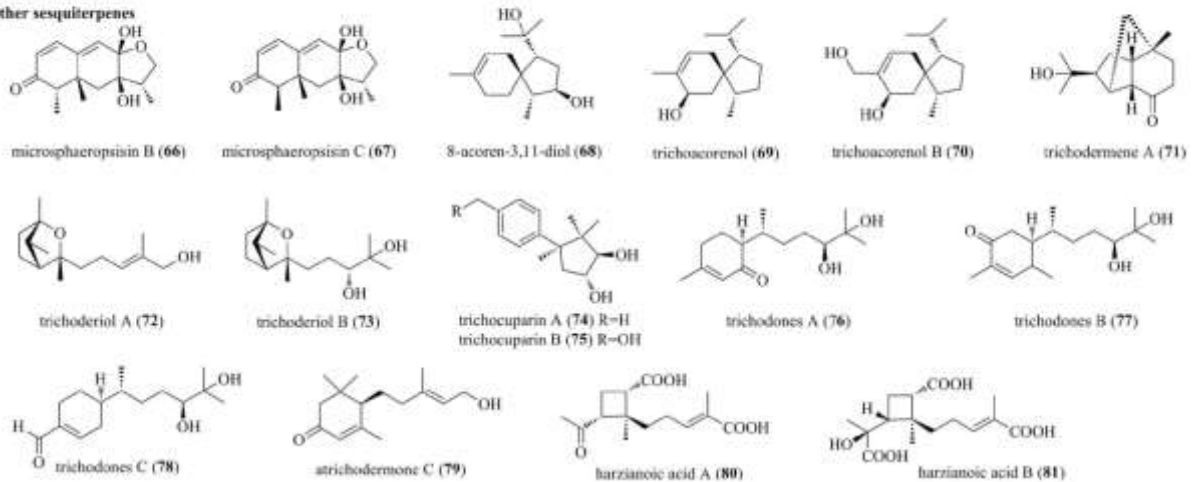


1. **Trichoderma turlari tomonidan ishlab chiqarilgan drimane va boshqa sesquiterpenlar. (53-81)**

**Drimane sesquiterpenes**



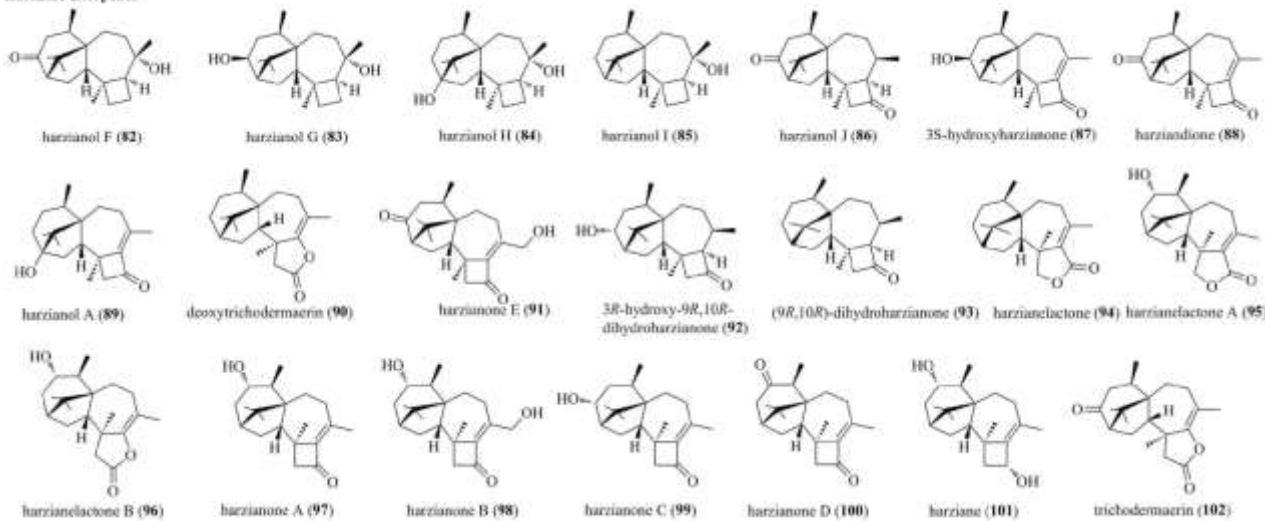
**Other sesquiterpenes**



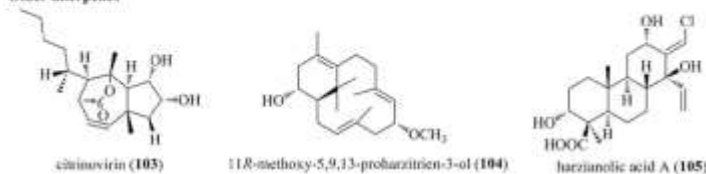


## 2. Trichoderma turlari tomonidan ishlab chiqarilgan Harzian va boshqa diterpenlar. (83-105)

### Harziane diterpenes

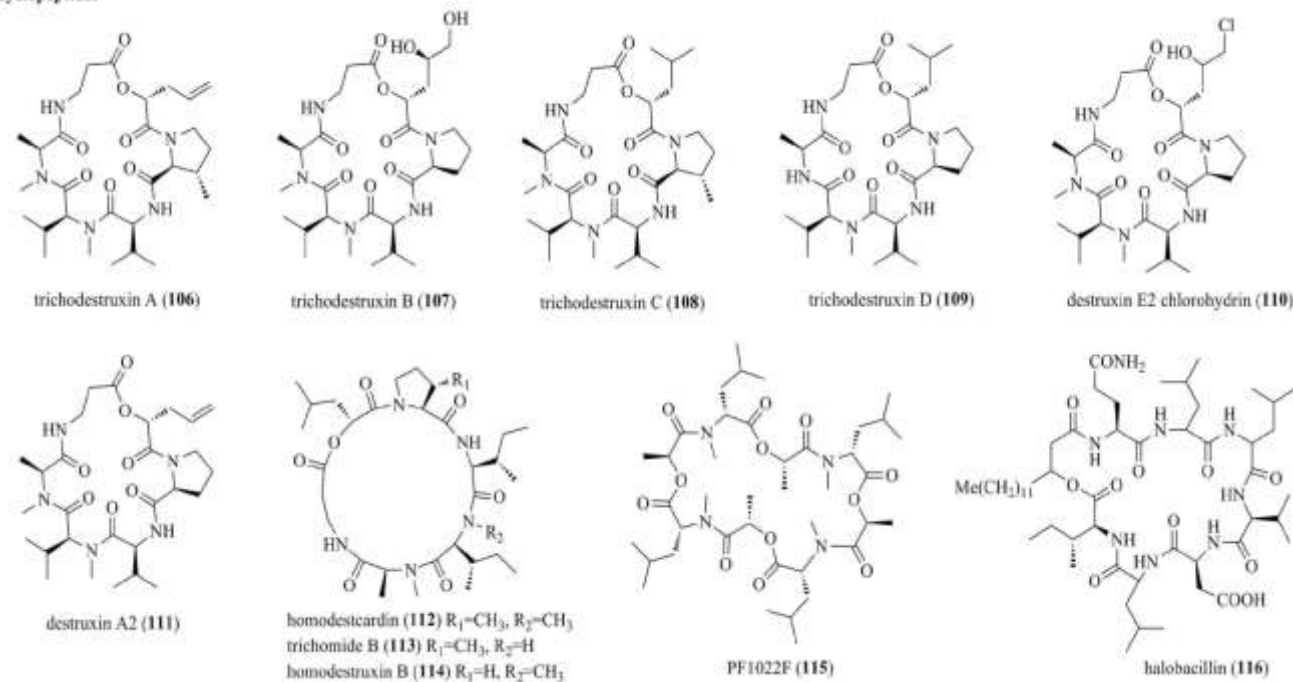


### Other diterpenes



## 3. Trichoderma turlari tomonidan ishlab chiqarilgan siklopeptidlar. (106-116)

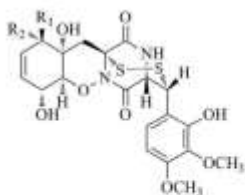
### Cyclopeptides



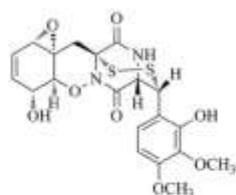


#### 4. Trichoderma turlari tomonidan ishlab chiqarilgan dikitopepirazinlar. (117-133)

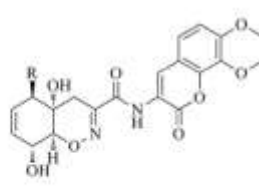
##### Diketopiperazines



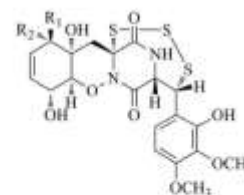
pretrichoderamide A (117)  $R_1=OH, R_2=H$   
DC1149B (120)  $R_1=Cl, R_2=H$   
DC1149R (122)  $R_1=Br, R_2=H$   
iododithiobrevamide (123)  $R_1=I, R_2=H$   
5-*epi*-pretrichoderamide A (126)  $R_1=H, R_2=OH$



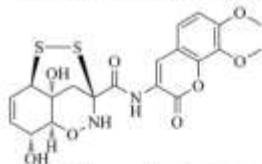
gliovirin (118)



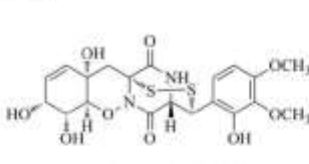
trichoderamide A (119)  $R=OH$   
trichoderamide B (121)  $R=Cl$



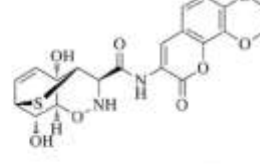
chlorotrithiobrevamide (124)  $R_1=Cl, R_2=H$   
5-*epi*-trithiopretrichoderamide A (127)  $R_1=H, R_2=OH$



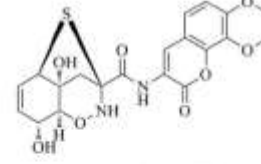
dithiospergillazine A (125)



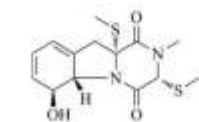
pretrichoderamide G (128)



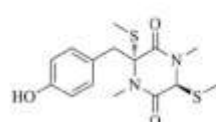
trichoderamide G (129)



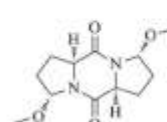
aspergillazine A (130)



dehydroxymethylbis(methylthio)gliotoxin (131)



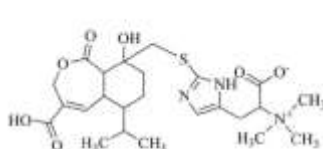
(3*S*,6*R*)-6-(*para*-hydroxybenzyl)-1,4-dimethyl-3,6-bis(methylthio)pyperazine-2,5-dione (132)



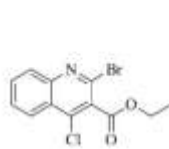
cyclo(L-5-MeOPro-L-5-MeO-Pro) (133)

#### 5. Trichoderma turlari tomonidan ishlab chiqarilgan alkaloidlar va boshqa azot o'z ichiga olgan birikmalar. (134-143)

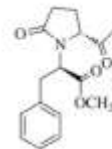
##### Alkaloids and other nitrogen-containing compounds



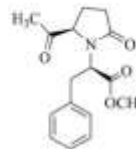
trichothionic acid (134)



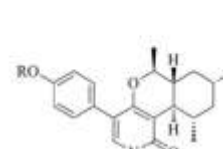
ethyl 2-bromo-4-chloroquinoline-3-carboxylate (135)



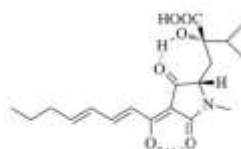
trichoderamide A (136)



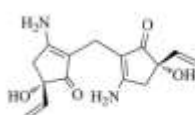
trichoderamide B (137)



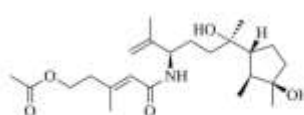
trichodin A (138)  $R=H$   
trichodin B (139)  $R=HO$



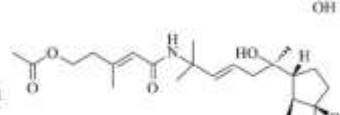
hazziamic acid (140)



atrichodermon A (141)



5'-acetoxy-deoxycyclonerin B (142)

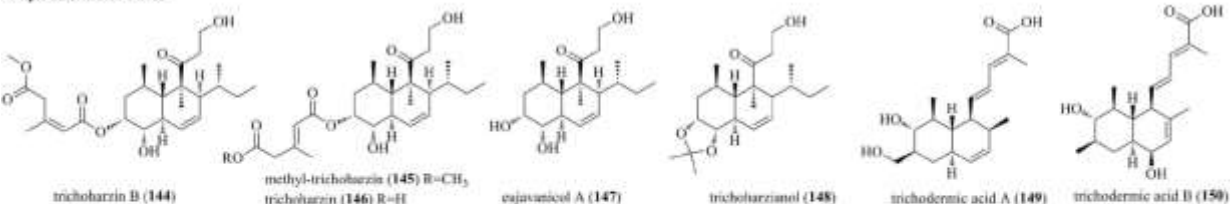


5'-acetoxy-deoxycyclonerin D (143)

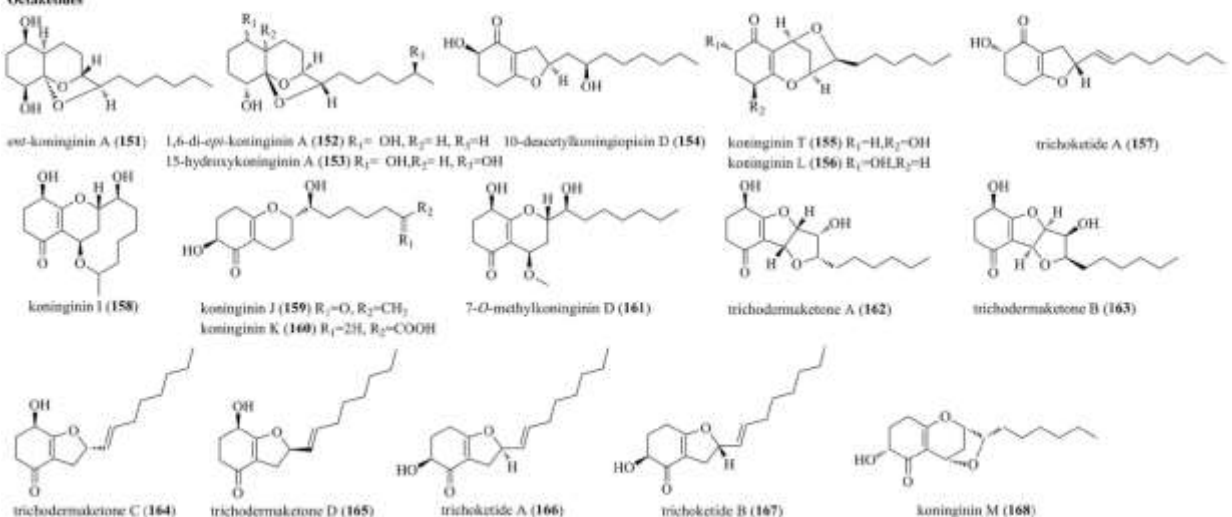


### 6. Trichoderma turlari tomonidan ishlab chiqarilgan naftalin va oktaketid hosilalari. (144-168)

#### Naphthalene derivatives

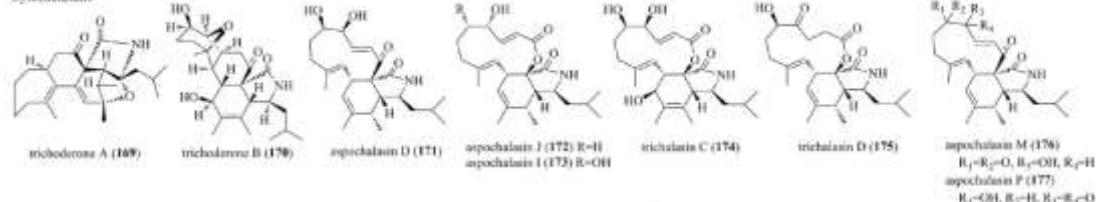


#### Octaketides

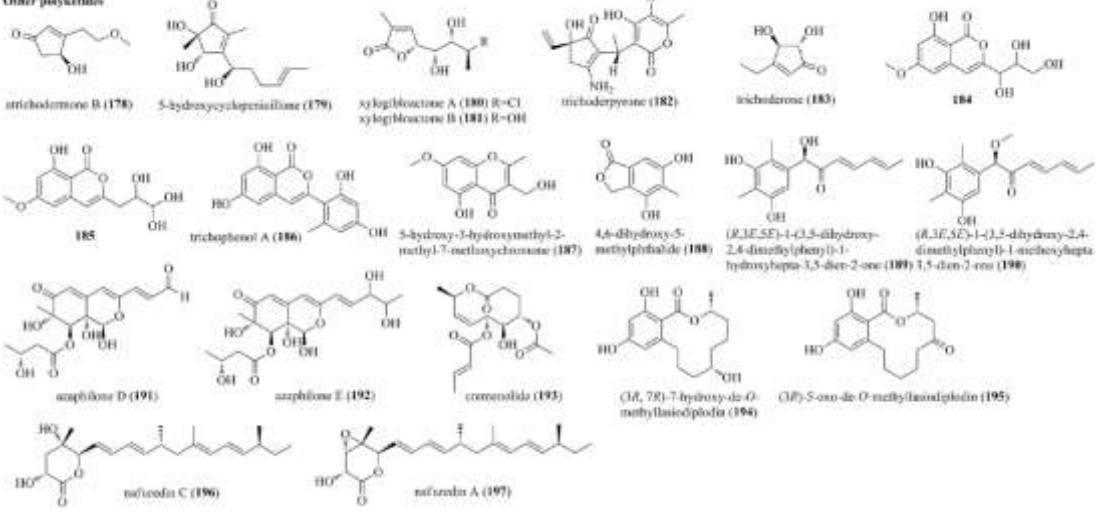


### 7. Trichoderma turlari tomonidan ishlab chiqarilgan sitokalazanlar va boshqa poliketidlar.(169-197)

#### Cytocalasam



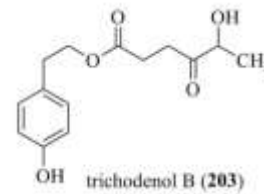
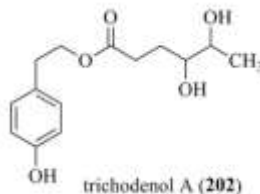
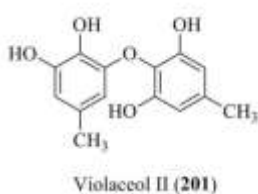
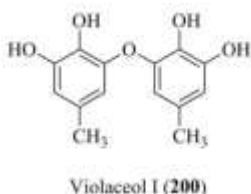
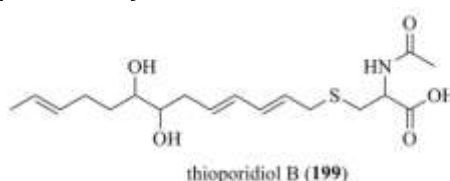
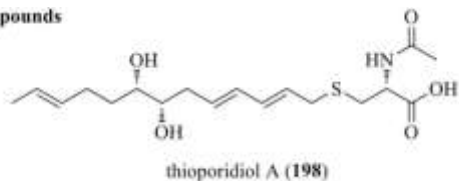
#### Other polyketides





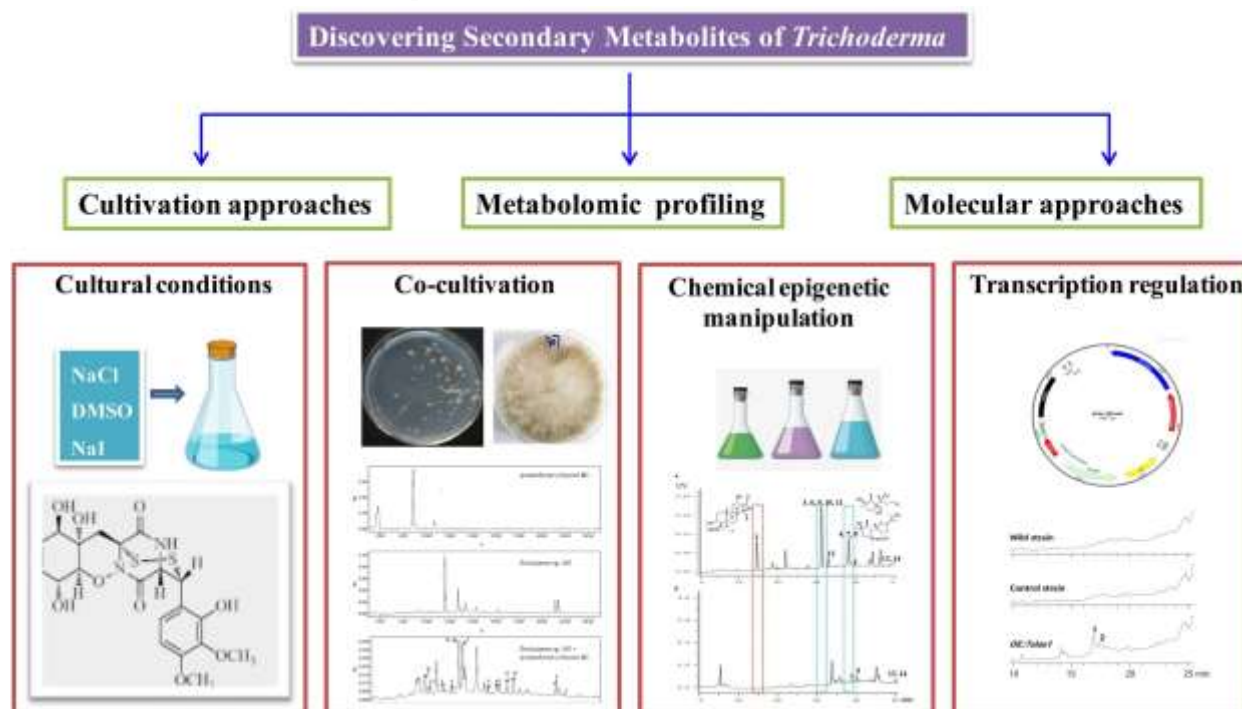
## 2. Trichoderma turlari tomonidan ishlab chiqarilgan boshqa brikmalar.(198-203)

Other compounds



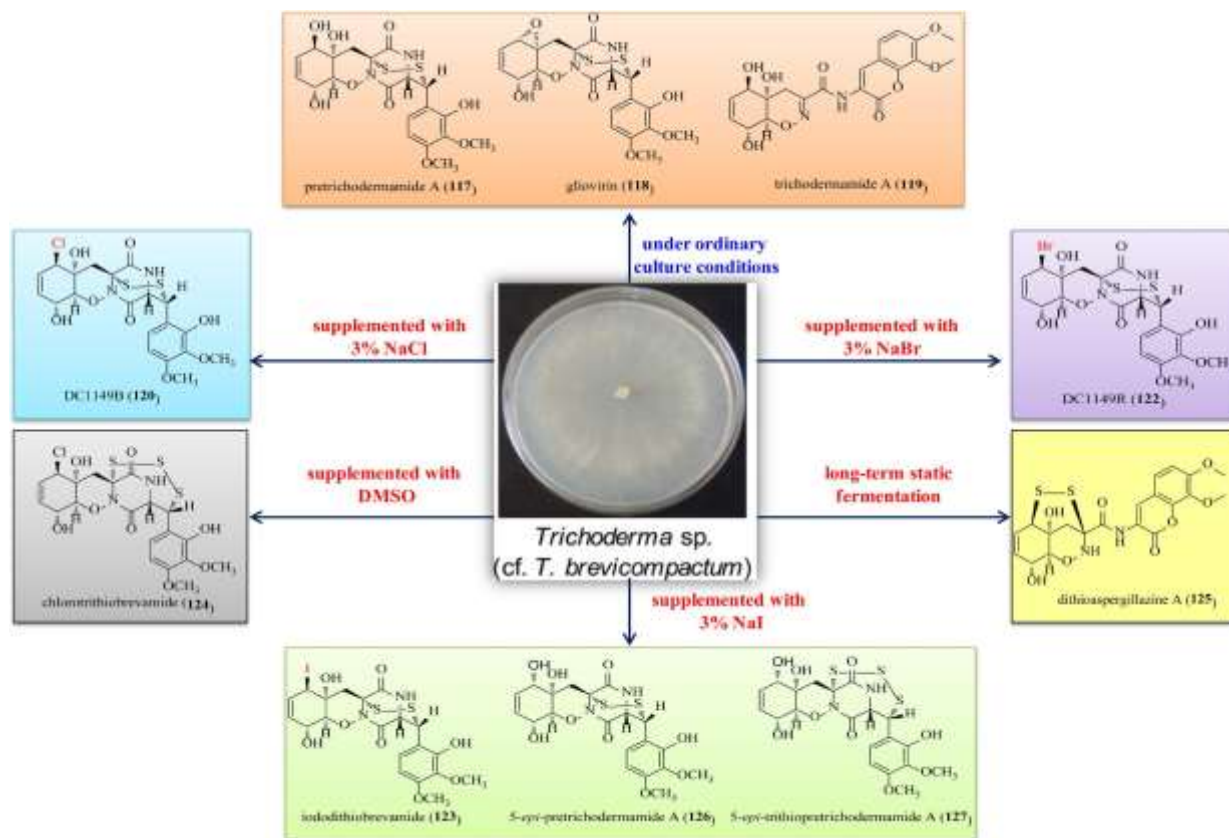
Trichodermaning ikkilamchi metabolitlarini kashf qilishning yangi strategiyalari.

Oxirgi zamburug' genamlari ketma ketligi ikkilamchi metabolitlar bilan bog'liq bo'lgan biosentetik gen klasterlarining ko'pchiligi sirli yoki umumiy laboratoriya sharoitida juda past darajada ifodalanganligini ko'rsatdi. Shuning uchun ko'p sonli ikkilamchi metabolitlarga qaramay Trichoderma bilan tavsiflanadi. Trichodermaning ikkilamchi metabolitlarini topishning odatiy misollari keltirilgan.



Trichodermaning ikkilamchi metabolitlarini oshishining yangi strategiyalari.

Dengizdan olingan qo'ziqorin Trichoderma sp TDU199 turli sharoitlarda bir qator diketopiperazinlarni ishlab chiqarishi aniqlandi.



*Trichoderma sp.* tomonidan ishlab chiqarilgan diketopiperazinlar TDU 199 turli sharoitlarda.

Tadqiqotlar shuni ko'rsatdiki transkripsiya nazorati ko'proq ikkilamchi metabolitlarni faollashtirish, *Trichoderma* turlarining barqaror potensial metabolizmini kuchaytirishda muqum bosqich bo'lishi mumkin.

Xulosa: *Trichoderma* tarixini o'rganmasdan ushbu jins ustida izlanishlar olib borish mushkul vazifa. *Trichoderma* tarixini o'rganish yaqin kelajak uchun juda katta muvaffaqiyatlar kalitidir. Chunki *Trichoderma* ildizlari hisoblangan ko'pchilik birikmalar o'rtacha va kuchli biologik faollikga ega. Ular orasida antimikrobiyal, antimikroalgal va saratonga qarshi faollik ko'rsatadigan muhim moddalar mavjud. Ushbu tabiiy mahsulotlarning salohiyatini baholash uchun dominant bioaktivlikni ifodalaydi. *Trichoderma*ning biokimyoviy tadqiqotlari hali qo'llanilmagan. *Trichoderma*dan ko'plab metabolitlar ajratilgan hamturlari bo'lsa, ushbu metabolitlarning keyingi tadqiqot ishlaridan natija kutishga arziydi. Ularning barqaror gen klasterlarini faollashtirish uchun yangi yondashuvlar, jumladan, yetishtirishga asoslangan yondashuvlar, metabolomik profillash va genom qazib olishga asoslangan molekulyar yondashuvlarni qo'llash orqali doimiy ravishda ko'payib borayotgan bioaktiv birikmalar olish mumkin, bu yaqin kelajakda yangi dori-darmonlarni kashf qilish uchun foydali bo'ladi.



**FOYDALANILGAN ADABIYOTLAR:**

1. Bhardwaj, N., and Kumar, J. (2017). Characterization of volatile secondary metabolites from *Trichoderma asperellum*. *J. Appl. Nat. Sci.* 9, 954–959. doi: 10.31018/jans.v9i2.1303
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5. Ding, G., Chen, A. J., Lan, J., Zhang, H., Chen, X., Liu, X., et al. (2012a). Sesquiterpenes and cyclopeptides from the endophytic fungus *Trichoderma asperellum* SAMUELS, LIECKF. & NIRENBERG. *Chem. Biodivers.* 9, 1205–1212. doi: 10.1002/cbdv.201100185
6. Ding, G., Chen, L., Chen, A., Tian, X., Chen, X., Zhang, H., et al. (2012b). Trichalasin C and D from the plant endophytic fungus *Trichoderma gamsii*. *Fitoterapia* 83, 541–544. doi: 10.1016/j.fitote.2011.12.021
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8. Ding, G., Chen, L., Zhou, C., Hong-Mei, J., Liu, Y. T., Chang, X., et al. (2015). Trichoderamides A and B, a pair of stereoisomers from the plant endophytic fungus *Trichoderma gamsii*. *J. Antibiot.* 68, 409–413. doi: 10.1038/ja.2015.1