Supplementary Material

A comprehensive investigation on chemical diversity and efficacy of different parts of *Ligusticum chuanxiong*

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Supplementary results

1. Identification of other phthalides

1.1 Identification of phthalide monomers

Peaks **46** and **51** presented similarly in its MS/MS spectrum a molecular ion at *m/z* 189.10 $[M+H]^+$ and the followed by its fragments at *m/z* 171.08 $[M+H-H_2O]^+$, 153.07 $[M+H-2H_2O]^+$, 143.09 $[M+H-H_2O-CO]^+$ and 117.07 $[M+H-CO_2-C_2H_4]^+$, in which peak **51** was identified as *Z*-butylidenephthalide in comparison with the reference material. The peak **46** has shorter retention time than peak **51** and was deduced as *E*- butylidenephthalide[1].

Peaks **38** and **40** produced molecular ions at *m/z* 193.12 $[M+H]^+$ and the higher intensity fragment ion at *m/z* 137.06 which was came from the losing of C_4H_8 and indicated the presence of 3-butyl substitution. Peak **38** was identified as senkyunolide A by reference components and literature data comparison[2,3], while peak **40** was preliminarily identified as 3-butyl-5,6-dihydro-4H-isobenzofuran-1-one by internal database.

A total of four peaks (peaks **10**, **42**, **45** and **49**) were extracted by molecular ion at *m/z* 195.14 $[M+H]^+$, and all of them generated the highest characteristic fragment ion at *m/z* 149.13 $[M+H-H_2O-CO]^+$. Four candidate structures were found by internal database search, including 3-carboxyethyl-phthalide (hydroxyl phthalide), cnidilide, neocnidilide and isocnidilide. Peak **10**, whose retention time was significantly shorter than other peaks, was identified as 3-carboxyethyl-phthalide (hydroxyl phthalide). Peaks **42**, **45** and **49** were tentatively identified as neocnidilide, cnidilide or isocnidilide[1,3].

Peak **55** with the molecular ion at *m/z* 197.15 $[M+H]^+$ and further produced the fragment ions at *m/z* 179.14 and *m/z* 151.15, corresponding to the neutral losses of H_2O and CO. According to search in internal database, it was matched with 3-butylhexahydro-1(3H)-isobenzofuranone.

The four isomers (peaks **26**, **30**, **33** and **35**) exhibited molecular ion at *m/z* 205.09 $[M+H]^+$. Among them, peaks **30** and **33** were precisely identified as senkyunolide C and 4-hydroxy-butylidenephthalide by reference materials, which both generated the product ions at *m/z* 187.08 ($[M+H-H_2O]^+$), 169.06 ($[M+H-2H_2O]^+$) and 159.08 ($[M+H-H_2O-CO]^+$). Peak **26** produced the fragment ions at *m/z* 149.06 ($[M+H-CH_3CHCO]^+$) and 103.05 ($[M+H-C_3H_6O-CO2]^+$), indicating that the structure of peak **26** might contains 9-OH substitution, and compared with reference material was identified as senkyunolide E. Peak **35** has the same MS^2 fragment as peaks **30** and **33**, but the retention time was longer. By the internal database, it was identified as 7-OH substituted *Z*-butylidenephthalide, known as senkyunolide B.

Peaks **16**, **21**, **23**, **28** and **29** were five isomers with the molecular ion at *m/z* 207.10 $[M+H]^+$. The retention time and mass spectrum fragments of peak **23** were consistent with the standard substance senkyunolide F, which was confidently identified as senkyunolide F. The molecular ion of peak **29** has the highest intensity, and further

generated the fragment ion at *m/z* 165.09 $[M+H-H_2O-CO]^+$. Those mass spectrum characteristic was consistent with literature data, hence peak **29** was inferred as 6,7-exoxyligustilide[4]. Peak **16** has a shorter retention time than other peaks, and without fragmentation ion at *m/z* 151.04. It was speculated that the hydroxyl group substitution might be in the side chain, and peak **16** was vaguely identified as 3-(3-Hydroxybutyl)-1(3H)-isobenzofuranone. Peaks **21** and **28** produced the fragment ions at *m/z* 161.10 ($[M+H-H_2O-CO]^+$) and 151.04 ($[M+H-C_4H_8]^+$), corresponding to 3-butyl substitution, so the hydroxyl group substituted hydrogen on the benzene ring. Searching in the internal database, peaks **21** and **28** were identified as 5-hydroxy-3-butylphthalide and 4-hydroxy-3-butylphthalide.

Peaks **20**, **22** and **25** all presented a molecular ion at *m/z* 209.12 $[M+H]^+$. Peaks **20** and **22** produced product ions at *m/z* 191.11 ($[M+H-H_2O]^+$), 163.11 ($[M+H-H_2O-CO]^+$), 153.05 ($[M+H-C_4H_8]^+$)and 145.10 ($[M+H-2H_2O-CO]^+$). The exact mass and the neutral loss of C_4H_8 provided a demonstration the existence of 3-butyl group and the same time a hydroxyl group attached to the ring (Table S3). Their most main difference was the intensity of fragment ion at *m/z* 153.05, in which peak **20** exhibited higher intensity than peak **22**. Combining the alternative structure, we surmised that there may be a 3-OH in the structure of peak **20**, which was more conducive to the formation of C^+ ion after the removal of C_4H_8. The above results were similarly to the characteristics of mass spectrum fragments of senkyunolide K and senkyunolide G in the literature, so we identified peaks **20** and **22** as senkyunolide K and senkyunolide G, respectively[2]. Peak **25** was 2H more than 6,7-exoxyligustilide, which could be observed from their mass difference in their precursor ions and product ions, and was tentatively inferred as (4*Z*)-4-butylidenehexahydrooxireno[e]isobenzofuran-6(1aH)-one by internal database.

Three isomers (peaks **5**, **13** and **15**) with the same molecular formula of $C_{12}H_{18}O_3$ exhibited precursor ion at *m/z* 211.13 $[M+H]^+$. Among them, peak **5** was identified as (3*S*,3a*R*,10*R*)-(-)-10-hydroxysedanolide by comparing with the MS/MS spectrum of reference material. Different from peak **5**, the *m/z* 119.09 fragment ion appeared in peaks **13** and **15**, which was caused by the neutral loss of $2H_2O$ and C_4H_8, indicating that the hydroxyl substitution occurred in the six-membered ring. Combining with the retention time of peaks **13** and **15** and the candidate structures in the internal database, we tentatively labeled them as (3*S*,3a*R*,4*R*)-4-hydroxy-sedanolide and (3*S*,3a*R*,6*S*)- -6-hydroxy-sedanolide respectively.

The peak **43** with molecular ion at *m/z* 219.10 $[M+H]^+$, which was 30 Da more than *Z*-butenylphthalide, and it was speculated that there was an additional OCH_3 substitution. The further fragment ion at *m/z* 204.08 $[M+H-CH_3\cdot]^+$, 186.07 $[M+H-H2O-CH_3\cdot]^+$ and 158.07 $[M+H-H_2O-CO-CH_3\cdot]^+$ were related to the loss of CH_3 radical, so it is speculated that OCH_3 substitution might be in the benzene ring. The speculated structure was searched in SCIFinder, and four potential structures were found, among which only (3*Z*)-3-butylidene-4-methoxy-1(3H)-isobenzofuranone came from natural products and was preliminarily matched with peak **43**.

Five isomers (Peaks **3**, **6**, **12**, **18** and **19**) produced the molecular ion at *m/z* 223.10 $[M+H]^+$ shown its theoretical molecular formula were $C_{12}H_{14}O_2$. Peak **19** exhibited the fragment ion at *m/z* 177.05 $([M+H-H_2O-C_2H_4])^+$, 135.04 $([M+H-H_2O-C_4H_6O])^+$, and 117.07 $([M+H-2H_2O-C_4H_6O])^+$ was identified as senkyunolide D[3,6]. Peaks **12** and **18** both provided the fragment ion at *m/z* 149.02 $([M+H-H_2O-C_4H_8])^+$, inferred that the possession of 3-butyl substitution. Based on the internal database, peaks **12** and **18** were ambiguously identified as 3-butyl-4,7-dihydroxyphthalide or 3-butyl-6,7-dihydroxyphthalide. Peaks **3** and **6** both appeared the fragment ion at *m/z* 205.09 $([M+H-H_2O])^+$ and *m/z* 149.06 $([M+H-H_2O-CO-C_2H_4])^+$, inferring that there might contain 3-butenyl group. According to the internal database, peaks **3** and **6** were ambiguously identified as (3*Z*)-3-butylidene-4,5-dihydro-4,5-dihydroxy-1(3H)-isobenzofuranone or (3*Z*)-3-butylidene-4,5-dihydro-6,7-dihydroxy-1(3H)-isobenzofuranone.

Peaks **1**, **2** and **8** produced the same mass spectrometry fragments, including molecular ion at *m/z* 227.13 $([M+H])^+$, and product ions at *m/z* 209.12 $([M+H-H_2O])^+$ and 153.05 $([M+H-H_2O-C_4H_8])^+$, which were consistent with the mass spectrum characteristics of senkyunolide J/N reported in the literature[5]. So peak **1** ,**2** and **8** were unambiguously identified as senkyunolide J, senkyunolide N or their steric isomer chuanxiongnolide R2.

Peaks **11** and **27** both were found the molecular ion at *m/z* 237.08 $[M+H]^+$. According to the structural characteristics of the phthalides, they were presumed to be butenylphthalide with three hydroxyl substitutions. A further fragment ion at *m/z* 191.03 $([M+H-H_2O-C_2H_4])^+$ implied that all three hydroxyl substituents are on the benzene ring. A candidate component, (*Z*)-3-butylidene-4,5,6-trihydroxy-1(3H)-isobenzofuranone was found in SciFinder based on the speculated structure. Therefore, peaks **11** and **27** were tentatively identified as (*Z*)-3-butylidene-4,5,6-trihydroxy- 1(3H)-isobenzofuranone and (*E*)-3-butylidene-4,5,6-trihydroxy-1(3H)-isobenzofuranone.

Peak **14** has a formula of $C_{13}H_{16}O_4$ (*m/z* 237.11 $[M+H]^+$), was identified as (+)-(*R*)-3-butyl-7-hydroxy-3-methoxyphthalide matched in internal database. The fragment ion at *m/z* 205.09 $([M+H-CH_3OH])^+$ was produced by *r*-H rearrangement of H-8 and removal of CH_3OH, and further generated the fragment ion at *m/z* 177.09 $([M+H-CH_3OH-CO])^+$ and 163.04 $([M+H-CH_3OH-C_3H_6])^+$.

Peak **7** with precursor ion at *m/z* 239.09 $[M+H]^+$, exhibited major fragment ions at *m/z* 203.07 $([M+H-H_2O])^+$, 179.03 $([M+H-H_2O-C_3H_6])^+$, and 165.02 $([M+H-C_4H_8])^+$. Based on the aforementioned information and internal

database, peak **7** was tentatively assigned as (3*R*)-3-butyl-3,6,7-trihydroxy-1(3H)-isobenzofuranone.

Peak **32** produced molecular ion at 243.08 $[M+H]^+$ corresponding to the molecular formula $C_{12}H_{15}O_3Cl$ and only one compound with this molecular formula was found in the internal database, known as senkyunolide L. The MS/MS fragment ion at *m/z* 207.10 was generated from the neutral loss of HCl, and the product ions produced by further fragmentation were consistent with that of 6,7-exoxyligustilide, including fragment ions at *m/z* 189.09, 161.10, 119.09, et al. Therefore, peak **32** was deduced as senkyunolide L[5].

Three isomers (peaks **31**, **34** and **36**) generated precursor ion at *m/z* 279.16 $[M+H]^+$, which suggested that their molecular formular were $C_{16}H_{22}O_4$, and speculated that their structures maybe contain a hydroxyl and a methoxyl substituent according to the structural characteristics of phthalides (Table S3). Among them, peaks **31** and **34** appeared a characteristic fragment at *m/z* 191.11, which produced by the neutral loss of H_2O and C_4H_6O. In addition, other common fragments were observed, such as *m/z* 233.15 $([M+H-H_2O-CO])^+$, 145.10 $[191-H_2O-CO]^+$ and 117.07 $[191-H_2O-CO-C_2H_4]^+$, which were consistent with the mass spectrum characteristics of senkyunolide M/Q reported in the literature[1,6]. Since the peaks **31** and **34** were provisionally assigned as senkyunolide M or senkyunolide Q. While peak **36** also has those common fragments above but no the characteristic fragment at *m/z* 191.11, it was suggested that the position of double bond at peak **36** was differed from peaks **31** and **34**. We speculated that there is a 6,7-alkene that prevents further disconnection of 6-COC_3H_7 and 7-OH. There is no compound with this structure in SciFinder, therefore, peak **36** was a potential new compound, named as 3-butyl-4,5-dihydro-7-hydroxy-6-(1-oxobutyl)-1(3H)-isobenzofuranone.

The peak **37** produced a precursor ion at *m/z* 177.09 $[M+H]^+$, which was 14 Da less than ligustilide, and came into being the neutral lost fragments of H_2O and CO as same as *Z*-ligustilide. Hence, we speculatd that peak **37** was a demethylated ligustilide, assigned as (*Z*)-propylidene phthalide by internal database. Similarly, the formulas for peak **17** ($C_{11}H_{14}O_2$, *m/z* 179.11) and **24** ($C_{11}H_{16}O_2$, *m/z* 181.12) were one methylene (14 Da) less than those for senkyunolide A and neocnidilide, respectively, and resulting in corresponding neutral loss of H_2O and CO. So peaks **17** and **24** were provisionally identified as (3*Z*)-4,5,6,7-tetrahydro-3-propylidene-1(3H)-isobenzofuranone and (3*R*,3a*R*)-3a,4,5,6-tetrahydro-3-propyl-1(3H)-isobenzofuranone respectively, the structures could be searched in SCIfinder.

1.2 Identification of phthalide dimers

Peak **70** presented precursor ions at *m/z* 379.19 $[M+H]^+$ and *m/z* 396.22 $[M+NH_4]^+$ and was exactly assigned as 4,5-dehydrodiligustilide by comparison with the retention time and mass spectrometry of the reference material.

There were 12 isomers (peaks **59**, **60**, **66**, **71**, **73**, **74**, **78**, **81**, **83**, **84**, **86** and **91**) owning molecular ion at *m/z* 381.20 $[M+H]^+$ and all of them presented the characteristic ion at *m/z* 191.11 with highest abundance, suggesting that their structure formed by the polymerization of two ligustilide. Among them, peaks **74**, **78**, **83** and **91** were identified as levistolide A, (3*Z*)-(3a*R*,6*S*,3'*R*,8*S*)-3a.8',6.3'-diligustilide, tokiaerialide and Z,Z'-3.3'a,7.7'a-diligustilide according to reference materials. The retention time of peaks **71** and **73** was close to that of peak **74**, so it was speculated that they were stereoisomers with the same polymerization mode. Combining with the literature data, they were tentatively identified as levistolide B and senkyunolide O[4]. Peak **84** has the close retention time and almost same mass spectrum fragment behavior compared with peak **83**, suggesting that peak **84** is the stereoisomer of peak **83**, a potential new compound, named as CI-1. The retention time of peak **86** was between peak **84** (3a.8',7a.3') and peak **91 (**3a.7a',7a.3a'**)**, according to above mentioned structure retention relationship of candidate compounds, it was tentatively assigned to neodiligustilide (3a.3',7a.8'). Similarly, peak **81** was identified as tokinolide A (3a.7',7a.6'). The other three peaks **59**, **60** and **66**, have shorter retention time and were tentatively matched to riligustilide, Z,Z'-3,3',8,8'-diligustilide and angelicolide, which could not be accurately identified due to the lack of reference materials.

Peaks **57**, **61**, **62**, **63**, **65**, **75**, **77**, **80**, **82** and **87** produced the molecular ions at *m/z* 383.22, and the DPIs at *m/z* 191.11 and 193.12, suggested that they were ten isomers and all combined by the polymerization of *Z*-ligustilide and senkyunolide A. Except for peak **87**, the other nine peaks showed the highest intensity fragment ions at *m/z* 191.11. In the current literature, only five phthalide dimers in accordance with above exact mass were reported with clear absolute configurations in plants of umbelliferae, i.e., chuanxiongdiolide R6, chaxiongnolide F, (*Z*)-3,8-dihydro-6,6',7,3'a-diligustilide, 3,8-dihydro-levistilide A and senkyunolide P. Unfortunately, as the reference material in this study, chuanxiongdiolide R6 was not detected in any part of L. *chuanxiong*. Peaks **61** and **65** presented a higher response, which were putatively identified as (*Z*)-3,8-dihydro-6,6',7,3'a-diligustilide and senkyunolide P based on the literature data, respectively [7]. The characteristic ion at *m/z* 191.11 in peak **87** was a non-base peak ion as same as reference substance chuanxiongdiolide R6,. It was speculated that peak **87** has a relatively stable structure and may be the trans-isomer of chuanxiongdiolide R6 (3a.3a',7a.7a'), that was, it has the polymerization mode of 3a.7a',7a.3a', was named as DI-6. The MS/MS spectrum of peak **62** was consistent with peak **61**, was identified as 3,8-dihydro-levistilide A[5], the stereoisomer of (*Z*)-3,8-dihydro-6,6',7,3'a-diligustilide. Peak **82** produced a product ion at *m/z* 225.16 $[M+H-C_6H_8O_2-H_2O-CO]^+$, corresponding the neutral loss of $C_6H_8O_2$ in

Z-ligustilide and H_2O and CO in senkyunolide A. It was deduced that the form of polymerization was 3a.7',7a.6', and was provisionally identified as chaxiongnolide F[4]. The rest 5 peaks (**57**, **63**, **75**, **77** and **80**) have no candidate structure to assign, were potential new compounds, named as DI-1~5.

Peak **68** presented a precursor ion at *m/z* 395.19 $[M+H]^+$, which was 16 Da (O) more than 4,5-dehydrodiligustilide. The MS/MS spectrum showed dominant product ions at *m/z* 191.11 $[M+H-C_{12}H_{12}O_3]^+$ and 205.09 $[M+H-C_{12}H_{14}O_2]^+$, corresponding to the depolymerization of the phthalide dimer in the MS/MS spectra. Thus, it was inferred that its structure type is BII (Table S4**)**. So far, no compound with similar structure has been reported, so it was speculated that this is a potential new compound, named as BII-1.

Two isomers (peaks **50** and **56**) have a molecular ion at *m/z* 397.20 $[M+H]^+$, which were presumed to be the monomer polymerization of a *Z*-ligustilide and a hydroxy-substituted *Z*-ligustilide (Table S4). Among them, peak **50** provided the highest intensity fragment ion at *m/z* 191.11, and further product ions at *m/z* 173.10 $[191.11-H_2O]^+$ and 145.10 $[191.11-H_2O-CO]^+$, corresponding to the structural fragment of *Z*-ligustilide. In accordance with accurate mass and structure feature were reported in the literature, peak **50** was identified as chuanxiongnolide A/B[8]. The another compound provided more fragment ions at *m/z* 361.18 $[M+H-2H_2O]^+$, 307.17 $[M+H-2H_2O-CO-C_2H_2]^+$ and 253.12 $[M+H-2H_2O-CO-C_2H_2-C_4H_6]^+$, and was considered to be different linking pattern between the monomers. Based on the neutral loss of C_2H_2 and C_4H_6, which formed by the undergo RDA cleavage of two six-membered rings, it was speculated that peak **56** is a potential new compound with the polymerization sites of 3.7',8.6', named as CII-1.

The phthalide dimer with molecular formula $C_{24}H_{30}O_5$ has two types of monomer binding, DII and CV (Table S4). In this experiment, four isomers, including peaks **53**, **54**, **64** and **76**, were found to have this molecular ion at *m/z* 399.22 $[M+H]^+$ based on the mass spectrum fragment information. Compared with the other two peaks, peaks **53** and **54** have shorter retention time and stronger abundance of fragment ions at *m/z* 335.20 ($[M+H-HCOOH]^+$), which were considered as CV type. Peaks **64** and **76** were considered as DII type on the contrary. The fragment ions and its intensity generated by peak **54** were consistent with that of levistolide A (CI), including *m/z* 381.20 $[M+H-H_2O]^+$, 353.21 $[M+H-H_2O-CO]^+$ and 191.11 $[M+H-C_{12}H_{16}O_3]^+$, etc. Therefore, it was speculated that of peak **54** has the same polymerization mode as levistolide A. Combining with literature data[1], peak **54** was accurately identified as demethywallichilide. The rest three compounds might be potential new compounds because no candidate structures have been found in internal database. Peak **53** produced product ions at *m/z* 363.18 $[M+H-2H_2O]^+$, 309.18 $[M+H-2H_2O-CO-C_2H_2]^+$, and 253.12 $[M+H-2H_2O-CO-C_2H_2-C_4H_6]^+$, which neutral lost was similarly to the MS/MS spectrum of peak **56**, suggesting that they had the same polymerization mode, assigned as CV-1. Except to the DPI at *m/z* 191.11, the characteristic ion at *m/z* 207.10 was also found in peak **64**, corresponding to a hydroxyl phthalide fragment, which further proved that it was the structural type of DII. Peak **64** was labeled as DII-1. However, due to the limited reference materials, it was not possible to further infer the connection mode between the two monomers and the position of substituents. The mass spectrogram of peak **76** was also inconsistent with peak **64**, indicating differences in the monomer polymerization mode or the position of substituents. Peak **76** was labeled as DII-2.

Peak **79** provided the quasi-molecular ion at *m/z* 401.23 $[M+H]^+$, and was more than 16 Da than chuanxiongdiolide R5. In addition, peak **79** presented the highest intensity fragment ion at *m/z* 191.11, a *Z*-ligustilide fragment, suggesting that its monomer polymerization type was EII (Table S4). Two candidate structures were matched from an internal database based on molecular formula retrieval. Interestingly, both of candidate structures were FII types, which were different from peak **79**. What's more, the retention time of F-type phthalide dimer is usually shorter than that of E-type phthalide dimer, while the retention time of peak **79** was longer than that of peak **58** (EI), which was obviously unreasonable to consider as FII type. Therefore, peak **79** was identified as a potential new compound with the EII structure type, labeled as EII-1.

Peaks **69** and **72** were extracted from the TIC chromatogram of QC sample corresponding to the molecular ion at *m/z* 413.23 $[M+H]^+$. They both produced high intensity fragment ions at *m/z* 191.11 $[M+H-C_{13}H_{19}O_3]^+$ and *m/z* 223.13 $[M+H-C_{12}H_{15}O_2]^+$, corresponding to the depolymerization of the phthalide dimer in the MS/MS spectra. Meanwhile, the peak **72** produced more product ions at *m/z* 353.17 $[M+H-CH_3COOH]^+$, 307.17 $[M+H-CH_3COOH-H_2O-CO]^+$ and 251.11 $[M+H-CH_3COOH-H_2O-CO-C_4H_8]$. They were presumed to be a pair of isomers of CIV type with different monomer polymerization method (Tab. S4). Among them, peak **69** showed higher response signal and was temporarily identified as wallichilide[1], while peak **72** was accurately identified as methyl ester derived from angeolide by comparing with the MS/MS spectra and retention time of reference material.

Peaks **39**, **47** and **52** presented the molecular ions at *m/z* 415.21 $[M+H]^+$ and 432.24 $[M+NH_4]^+$, corresponding to a molecular formula of $C_{24}H_{30}O_6$. In addition, they provided the DPIs at *m/z* 191.11 or 193.12, corresponding to the depolymerization of the phthalide dimer, as well as the highest intensity fragment ion at *m/z* 119.09 $[193.12-C_4H_8-H_2O]^+$, corresponding to a product ion of senkyunolide A. According to the structural features and molecular formula of the phthalide dimer, they were inferred to be DIII type (Table S4). A candidate compound, chuanxiongnolides L5[9], was matched from the internal database. Due to the lack of reference material and more

detailed MS/MS data, it was difficult to identify them more accurately. Peaks **39**, **47** and **52** were deduced as chuanxiongnolide L5 or its isomers.

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Supplementary Figures

Fig. S1 In the positive ion mode, the TIC chromatogram of QC sample by UHPLC/Q-Orbitrap MS Analysis (I) and EIC chromatogram of each compound (II).

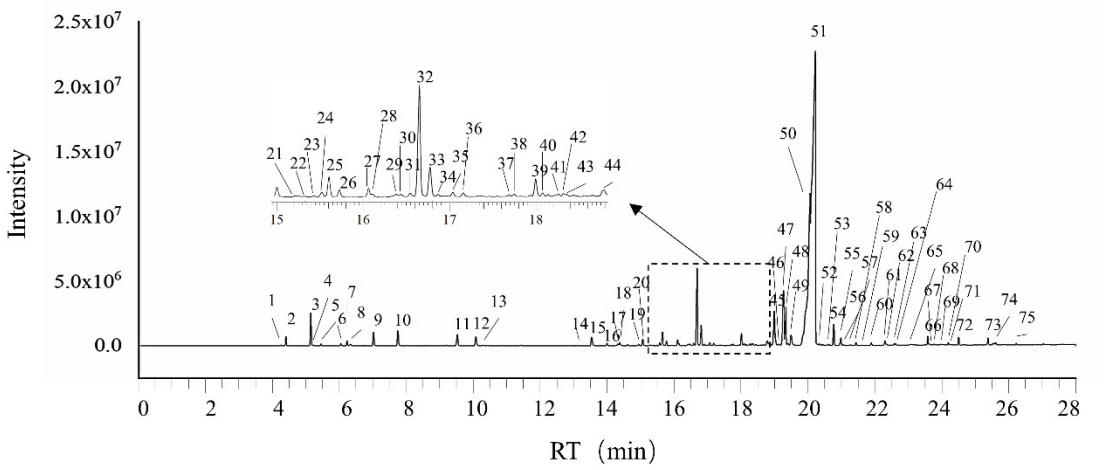

Fig. S2 Assignment of the identified peaks in GC-MS TIC chromatograms in QC sample of volatile oil

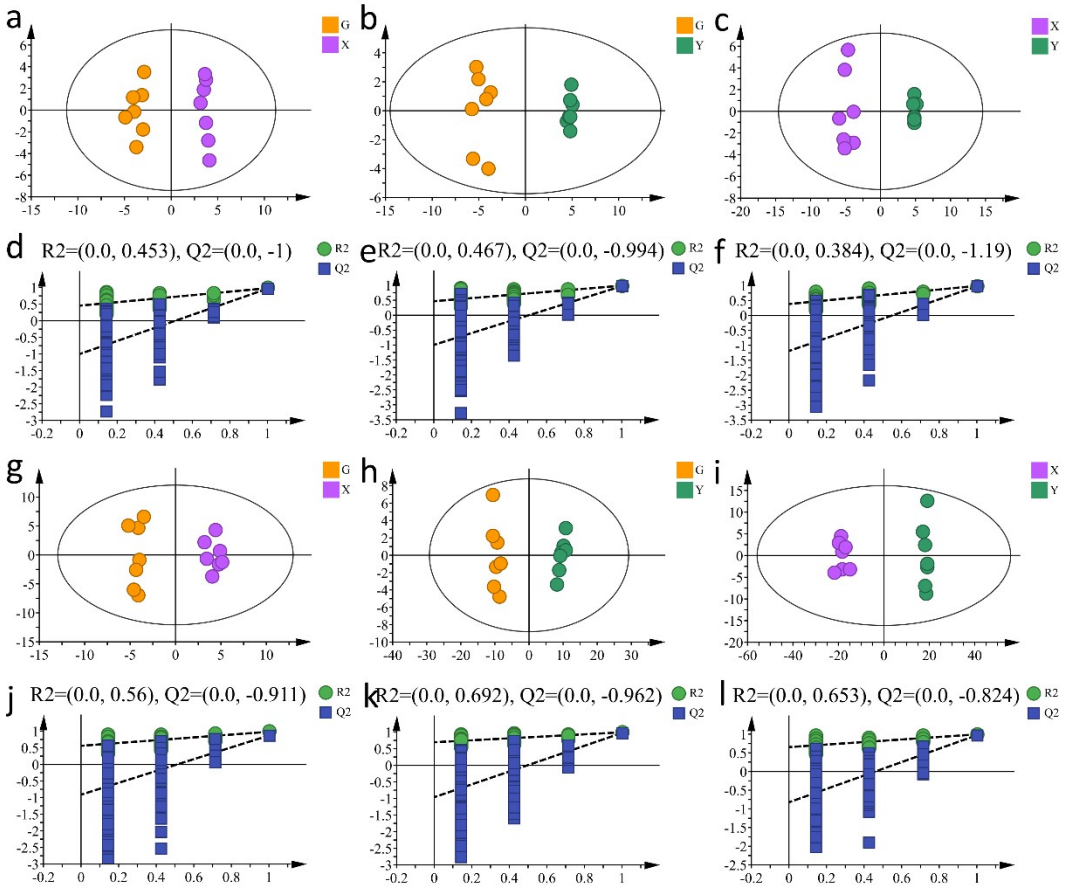

Fig. S3 Score scatter plots and validation plots of OPLS-DA for volatile oil and methanol extract from three parts of CX. OPLS-DA for X/G, Y/G and Y/X comparative groups of volatile oil, respectively (a-c). Validation plots of OPLS-DA for X/G, Y/G and Y/X comparative groups of volatile oil, respectively (d-f). OPLS-DA for X/G, Y/G and Y/X comparative groups of methanol extract, respectively (g-i). Validation plots of OPLS-DA for X/G, Y/G and Y/X.

Supplementary Tables

Table S1 All compounds were characterized in different parts of CX by UHPLC/Q-Orbitrap MS Analysis

No.	RT [min]	Identification	Formula	Theoretical Mass (Da)	Calculated Mass (Da)	Error (ppm)	Class	X vs. G	Y vs. G
1	0.826	DL-lysine	$C_6H_{14}N_2O_2$	147.1128 $[M+H]^+$	147.1127 $[M+H]^+$	-0.71	amino acids	↓	-
2	0.837	L-histidine	$C_6H_9N_3O_2$	156.0768 $[M+H]^+$	156.0766 $[M+H]^+$	-0.98	amino acids	-	-
3	0.859	DL-arginine	$C_6H_{14}N_4O_2$	175.1190 $[M+H]^+$	175.1188 $[M+H]^+$	-0.87	amino acids	↓	↓***
4	0.887	choline	$C_5H_{13}NO$	104.1070 $[M+H]^+$	104.1073 $[M+H]^+$	2.972	alkaloids	-	-
5	0.897	D-(-)-glutamine	$C_5H_{10}N_2O_3$	147.0764 $[M+H]^+$	147.0761 $[M+H]^+$	-2.17	amino acids	-	-
6	0.9	asparagine	$C_4H_8N_2O_3$	133.0608 $[M+H]^+$	133.0606 $[M+H]^+$	-1.27	amino acids	-	↓***
7	0.902	threonine	$C_4H_9NO_3$	120.0655 $[M+H]^+$	120.0655 $[M+H]^+$	-0.16	amino acids	-	↓***
8	0.908	gluconic acid	$C_6H_{12}O_7$	195.0499 $[M-H]^-$	195.0504 $[M-H]^-$	2.414	saccharides	↓**	↓***
9	0.908	D-raffinose	$C_{18}H_{32}O_{16}$	503.1607 $[M-H]^-$	503.1619 $[M-H]^-$	2.462	saccharides	-	-
10	0.913	nystose	$C_{24}H_{42}O_{21}$	665.2135 $[M-H]^-$	665.2151 $[M-H]^-$	2.429	saccharides	-	↓***
11	0.918	α,α-trehalose	$C_{12}H_{22}O_{11}$	341.1078 $[M-H]^-$	341.1086 $[M-H]^-$	2.234	saccharides	-	-
12	0.928	D-(-)-quinic acid	$C_7H_{12}O_6$	193.0707 $[M+H]^+$	193.0705 $[M+H]^+$	-0.85	others	-	-
13	0.929	D-(-)-fructose	$C_6H_{12}O_6$	179.0550 $[M-H]^-$	179.0554 $[M-H]^-$	2.234	saccharides	-	↑***
14	0.944	cytidine	$C_9H_{13}N_3O_5$	244.0928 $[M+H]^+$	244.0925 $[M+H]^+$	-1.22	nucleosides	-	↓***
15	0.957	adenine	$C_5H_5N_5$	136.0618 $[M+H]^+$	136.0616 $[M+H]^+$	-1.26	amino acids	-	-
16	0.964	adenosine	$C_{10}H_{13}N_5O_4$	268.1040 $[M+H]^+$	268.1037 $[M+H]^+$	-1.23	nucleosides	-	↓***
17	0.967	pipecolic acid	$C_6H_{11}NO_2$	130.0863 $[M+H]^+$	130.0865 $[M+H]^+$	1.882	alkaloids	-	-
18	0.971	citric acid	$C_6H_8O_7$	191.0186 $[M-H]^-$	191.0193 $[M-H]^-$	3.513	short-chain fatty acids	-	↓***
19	0.975	trans-aconitic acid	$C_6H_6O_6$	173.0081 $[M-H]^-$	173.0083 $[M-H]^-$	1.362	short-chain fatty acids	-	↓***
20	0.976	2-hydroxyphenylalanine	$C_9H_{11}NO_3$	182.0812 $[M+H]^+$	182.0809 $[M+H]^+$	-1.48	amino acids	-	-
21	0.984	shikimic acid	$C_7H_{10}O_5$	173.0444 $[M-H]^-$	173.045 $[M-H]^-$	3.179	short-chain fatty acids	-	↑***
22	1.013	4-oxoproline	$C_5H_7NO_3$	130.0499 $[M+H]^+$	130.0498 $[M+H]^+$	-0.54	nucleosides	↓***	-
23	1.211	uridine	$C_9H_{12}N_2O_6$	245.0768 $[M+H]^+$	245.0763 $[M+H]^+$	-2.09	nucleosides	-	-
24	1.212	nicotinic acid	$C_6H_5NO_2$	124.0393 $[M+H]^+$	124.0394 $[M+H]^+$	0.766	alkaloids	-	-
25	1.218	isocitric acid	$C_6H_8O_7$	191.0186 $[M-H]^-$	191.0192 $[M-H]^-$	2.989	short-chain fatty acids	-	↓***
26	1.236	cis-aconitic acid	$C_6H_6O_6$	173.0081 $[M+H]^+$	173.008 $[M+H]^+$	-0.37	short-chain fatty acids	-	↓***
27	1.257	2'-deoxyadenosine	$C_{10}H_{13}N_5O_3$	252.1091 $[M+H]^+$	252.109 $[M+H]^+$	-0.46	nucleosides	-	-
28	1.291	DL-norleucine	$C_6H_{13}NO_2$	132.1019 $[M+H]^+$	132.1018 $[M+H]^+$	-0.8	amino acids	↓**	↓
29	1.293	guanine	$C_5H_5N_5O$	152.0567 $[M+H]^+$	152.0565 $[M+H]^+$	-1.23	nucleosides	-	-
30	1.295	guanosine	$C_{10}H_{13}N_5O_5$	284.0989 $[M+H]^+$	284.0986 $[M+H]^+$	-1.21	nucleosides	-	-
31	1.308	2-hydroxycinnamic acid	$C_9H_8O_3$	165.0546 $[M+H]^+$	165.0545 $[M+H]^+$	-0.73	phenolic acids	-	-
32	1.496	isoleucine	$C_6H_{13}NO_2$	132.1019	132.1016	-2.31	amino acids	-	-

				$[M+H]^+$	$[M+H]^+$				
33	1.542	2'-O-methyladenosine	$C_{11}H_{15}N_5O_4$	282.1197 $[M+H]^+$	282.1193 $[M+H]^+$	-1.35	nucleosides	-	-
34	1.595	valylproline	$C_{10}H_{18}N_2O_3$	215.1390 $[M+H]^+$	215.1389 $[M+H]^+$	-0.55	amino acids	↓**	↓***
35	1.685	2'-O-methylguanosine	$C_{11}H_{15}N_5O_5$	298.1146 $[M+H]^+$	298.1141 $[M+H]^+$	-1.66	nucleosides	-	↓***
36	1.833	5-(hydroxymethyl)-4-methoxy-2,5-dihydrofuran-2-one	$C_6H_8O_4$	145.0495 $[M+H]^+$	145.0494 $[M+H]^+$	-0.93	others	↑*	↑***
37	1.885	thymine	$C_5H_6N_2O_2$	127.0502 $[M+H]^+$	127.0503 $[M+H]^+$	0.756	nucleosides	↓***	-
38	2.202	L-phenylalanine	$C_9H_{11}NO_2$	166.0863 $[M+H]^+$	166.086 $[M+H]^+$	-1.54	amino acids	-	-
39	2.288	pantothenic acid	$C_9H_{17}NO_5$	220.1179 $[M+H]^+$	220.1176 $[M+H]^+$	-1.59	alkaloids	-	-
40	2.713	protocatechuic acid	$C_7H_6O_4$	153.0182 $[M-H]^-$	153.0185 $[M-H]^-$	1.731	aromatic acids and its esters	-	↑***
41	2.74	glycyl-L-leucine	$C_8H_{16}N_2O_3$	189.1234 $[M+H]^+$	189.1232 $[M+H]^+$	-0.89	amino acids	↓***	↓***
42	2.806	neochlorogenic acid	$C_{16}H_{18}O_9$	355.1024 $[M+H]^+$	355.1017 $[M+H]^+$	-1.85	phenylethanoid glycosides	↑***	↑***
43	2.825	pyrpgallol	$C_6H_6O_3$	127.0390 $[M+H]^+$	127.0389 $[M+H]^+$	-0.56	short-chain fatty acids	-	↑
44	2.85	5'-S-methyl-5'-thioadenosine	$C_{11}H_{15}N_5O_3S$	298.0968 $[M+H]^+$	298.0966 $[M+H]^+$	-0.79	alkaloids	↑***	↑***
45	3.027	leucylproline	$C_{11}H_{20}N_2O_3$	229.1547 $[M+H]^+$	229.1544 $[M+H]^+$	-1.17	amino acids	↓**	↓***
46	3.046	esculin	$C_{15}H_{16}O_9$	341.0867 $[M+H]^+$	341.0864 $[M+H]^+$	-0.9	coumarins	-	↑***
47	3.048	3-O-(β-D-glucopyranosyl)-caffeoyl quinic acid	$C_{22}H_{28}O_{14}$	517.1552 $[M+H]^+$	517.1553 $[M+H]^+$	0.228	phenylethanoid glycosides	↑	-
48	3.122	2,3,5,6-tetramethylpyrazine	$C_8H_{12}N_2$	137.1073 $[M+H]^+$	137.1072 $[M+H]^+$	-0.91	alkaloids	↓	↓***
49	3.126	(3aR,4aS,5R,7aS,8S,9aR)-5-hydroxy-4a,8-dimethyl-3-methyleneoctahydroazuleno[6,5-b]furan-2,6(3H,4H)-dione	$C_{15}H_{20}O_4$	265.1434 $[M+H]^+$	265.1432 $[M+H]^+$	-0.89	others	-	-
50	3.224	L-tryptophan	$C_{11}H_{12}N_2O_2$	205.0972 $[M+H]^+$	205.097 $[M+H]^+$	-0.75	amino acids	-	-
51	3.226	4-indolecarbaldehyde	C_9H_7NO	146.0600 $[M+H]^+$	146.0599 $[M+H]^+$	-0.96	alkaloids	-	-
52	3.227	indole-3-acrylic acid	$C_{11}H_9NO_2$	188.0706 $[M+H]^+$	188.0704 $[M+H]^+$	-1.09	short-chain fatty acids	-	-
53	3.469	caffeic acid	$C_9H_8O_4$	181.0495 $[M+H]^+$	181.0492 $[M+H]^+$	-1.85	phenolic acids	↑***	↑***
54	3.47	chlorogenic acid	$C_{16}H_{18}O_9$	355.1024 $[M+H]^+$	355.1014 $[M+H]^+$	-2.7	phenylethanoid glycosides	↑***	↑***
55	3.507	2,5-dihydroxybenzaldehyde	$C_7H_6O_3$	139.0390 $[M+H]^+$	139.0389 $[M+H]^+$	-0.51	phenolic acids	-	↑***
56	3.54	7-hydroxy-6-methoxy-2H-chromen-2-one	$C_{10}H_8O_4$	193.0495 $[M+H]^+$	193.0493 $[M+H]^+$	-1.22	coumarins	-	↑***
57	3.617	isofraxidin	$C_{11}H_{10}O_5$	223.0601 $[M+H]^+$	223.0598 $[M+H]^+$	-1.34	coumarins	↑***	↓***

58	3.64	cryptochlorogenic acid	$C_{16}H_{18}O_9$	355.1024 $[M+H]^+$	355.1017 $[M+H]^+$	-1.85	phenylethanoid glycosides	↑***	↑***
59	3.765	gentisic acid	$C_7H_6O_4$	153.0182 $[M-H]^-$	153.0185 $[M-H]^-$	1.731	aromatic acids and its esters	-	-
60	3.782	fraxetin	$C_{10}H_8O_5$	209.0444 $[M+H]^+$	209.0443 $[M+H]^+$	-0.72	coumarins	↑***	-
61	4.028	2,4-dihydroxycinnamic Acid	$C_9H_8O_4$	181.0495 $[M+H]^+$	181.0495 $[M+H]^+$	-0.19	phenolic acids	-	↑**
62	4.049	2-(2-amino-3-methylbutanamido)-3-phenylpropanoic acid	$C_{14}H_{20}N_2O_3$	265.1547 $[M+H]^+$	265.1546 $[M+H]^+$	-0.26	alkaloids	↓**	↓***
63	4.056	isophthalic acid	$C_8H_6O_4$	167.0339 $[M+H]^+$	167.0342 $[M+H]^+$	1.885	aromatic acids and its esters	-	↓***
64	4.087	4-caffeoylquinic acid	$C_{16}H_{18}O_9$	355.1024 $[M+H]^+$	355.1019 $[M+H]^+$	-1.29	phenylethanoid glycosides	↑***	↑***
65	4.108	2,3,4,9-tetrahydro-1H-β-carboline-3-carboxylic acid	$C_{12}H_{12}N_2O_2$	217.0972 $[M+H]^+$	217.0971 $[M+H]^+$	-0.25	alkaloids	↓**	↓***
66	4.134	vallinic acid	$C_8H_8O_4$	169.0495 $[M+H]^+$	169.0493 $[M+H]^+$	-1.39	phenolic acids	-	↓***
67	4.174	3-O-p-coumaroylquinic acid	$C_{16}H_{18}O_8$	339.1074 $[M+H]^+$	339.1071 $[M+H]^+$	-1.01	phenylethanoid glycosides	-	↑***
68	4.258	4,5-dicaffeoylquinic acid	$C_{25}H_{24}O_{12}$	517.1341 $[M+H]^+$	517.1339 $[M+H]^+$	-0.3	phenylethanoid glycosides	-	↑***
69	4.44	3-hydroxyscopoletin	$C_{10}H_8O_5$	209.0444 $[M+H]^+$	209.0441 $[M+H]^+$	-1.67	coumarins	↑***	-
70	4.464	3-feruloylquinic acid	$C_{17}H_{20}O_9$	369.1180 $[M+H]^+$	369.1178 $[M+H]^+$	-0.57	phenylethanoid glycosides	-	-
71	4.467	(Z)-ferulic acid	$C_{10}H_{10}O_4$	195.0652 $[M+H]^+$	195.0651 $[M+H]^+$	-0.44	phenolic acids	-	-
72	4.482	N-acetyl-D-alloisoleucine	$C_8H_{15}NO_3$	174.1125 $[M+H]^+$	174.1125 $[M+H]^+$	0.173	amino acids	-	-
73	4.77	cyclo(leucylprolyl)	$C_{11}H_{18}N_2O_2$	211.1441 $[M+H]^+$	211.1441 $[M+H]^+$	-0.02	alkaloids	↓***	↓***
74	4.881	rutin	$C_{27}H_{30}O_{16}$	611.1607 $[M+H]^+$	611.1599 $[M+H]^+$	-1.25	flavonoids	-	↑***
75	4.883	phenylalanine	$C_{10}H_{13}NO_2$	180.1019 $[M+H]^+$	180.1017 $[M+H]^+$	-1.14	alkaloids	↑	↑***
76	4.923	vanillin	$C_8H_8O_3$	153.0546 $[M+H]^+$	153.0546 $[M+H]^+$	-0.14	phenolic acids	-	↓***
77	4.933	2,4-dihydroxybenzoic acid	$C_7H_6O_4$	153.0182 $[M-H]^-$	153.0185 $[M-H]^-$	1.731	aromatic acids and its esters	-	↑***
78	5.104	quercetin-3β-D-glucoside	$C_{21}H_{20}O_{12}$	465.1028 $[M+H]^+$	465.1025 $[M+H]^+$	-0.54	flavonoids	-	↑***
79	5.2	3-O-neohesperidoside kaempferol	$C_{27}H_{30}O_{15}$	595.1657 $[M+H]^+$	595.1655 $[M+H]^+$	-0.41	flavonoids	-	↑***
80	5.227	scopoletin	$C_{10}H_8O_4$	193.0495 $[M+H]^+$	193.0493 $[M+H]^+$	-1.22	coumarins	-	↑***
81	5.307	(E)-ferulic acid	$C_{10}H_{10}O_4$	195.0652 $[M+H]^+$	195.0652 $[M+H]^+$	0.075	phenolic acids	-	↓***
82	5.379	fraxinol	$C_{11}H_{10}O_5$	223.0601 $[M+H]^+$	223.06 $[M+H]^+$	-0.45	coumarins	↑***	↓***
83	5.478	2-(2,6-dihydroxyphenyl)-3,5,7-trihydroxy-4H-chromen-4-one	$C_{15}H_{10}O_7$	303.0499 $[M+H]^+$	303.0497 $[M+H]^+$	-0.76	flavonoids	-	↑***
84	5.482	trifolin	$C_{21}H_{20}O_{11}$	449.1078 $[M+H]^+$	449.1078 $[M+H]^+$	-0.08	flavonoids	-	↑***
85	5.483	kaempferol	$C_{15}H_{10}O_6$	287.0550	287.0546	-1.44	flavonoids	-	↑***

				[M+H]+	[M+H]+				
86	5.516	1,3-dicaffeoyl quinic acid	$C_{25}H_{24}O_{12}$	517.1341 [M+H]+	517.1337 [M+H]+	-0.68	phenylethanoid glycosides	-	↑***
87	5.666	1-caffeoylquinic acid	$C_{16}H_{18}O_9$	355.1024 [M+H]+	355.1017 [M+H]+	-1.85	phenylethanoid glycosides	-	↑***
88	5.67	cis-caffeic acid	$C_9H_8O_4$	181.0495 [M+H]+	181.0493 [M+H]+	-1.3	phenolic acids	-	↑***
89	5.829	quercetin	$C_{15}H_{10}O_7$	303.0499 [M+H]+	303.0497 [M+H]+	-0.76	flavonoids	-	↑***
90	5.83	6"-O-acetylisoquercitrin	$C_{23}H_{22}O_{13}$	507.1133 [M+H]+	507.1133 [M+H]+	-0.03	flavonoids	-	↑***
91	5.831	3-{[(2R,3S,4S,5R,6S)-6-{[2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-4-oxo-4H-chromen-3-yl]oxy}-3,4,5-trihydroxyoxan-2-yl]methoxy}-3-oxopropanoic acid	$C_{24}H_{22}O_{15}$	551.1031 [M+H]+	551.1029 [M+H]+	-0.45	others	-	↑***
92	5.832	6,8-dihydroxy-7-methoxy-3-methylisocoumarin	$C_{11}H_{10}O_5$	223.0601 [M+H]+	223.0599 [M+H]+	-0.9	others	↑**	-
93	5.91	senkyunolide J/N 1	$C_{12}H_{18}O_4$	227.1278 [M+H]+	227.1274 [M+H]+	-1.7	phthalide monomers	-	↓***
94	5.91	3-methylsalicylic acid	$C_8H_8O_3$	153.0546 [M+H]+	153.0545 [M+H]+	-0.79	aromatic acids and its esters	-	↓***
95	5.98	1,3-dicaffeoylquinic acid	$C_{25}H_{24}O_{12}$	517.1341 [M+H]+	517.1332 [M+H]+	-1.65	phenylethanoid glycosides	-	↑***
96	6.054	2-indolecarbaldehyde	C_9H_7NO	146.0600 [M+H]+	146.0599 [M+H]+	-0.96	alkaloids	↓***	-
97	6.066	2-(2,4-dihydroxyphenyl)-3,5,7-trihydroxy-4H-chromen-4-one	$C_{15}H_{10}O_7$	303.0499 [M+H]+	303.0496 [M+H]+	-1.09	flavonoids	-	↑***
98	6.21	azelaic acid	$C_9H_{16}O_4$	187.0965 [M-H]-	187.0969 [M-H]-	2.216	short-chain fatty acids	-	↑***
99	6.312	senkyunolide J/N 2	$C_{12}H_{18}O_4$	227.1278 [M+H]+	227.1274 [M+H]+	-1.7	phthalide monomers	↓***	↓***
100	6.346	(3Z)-3-butylidene-4,5-dihydro-4,5-dihydroxy-1(3H)-isobenzofuranone	$C_{12}H_{14}O_4$	223.0965 [M+H]+	223.0964 [M+H]+	-0.38	phthalide monomers	-	↓***
101	6.486	3,4,5-tricaffeoylquinic acid	$C_{34}H_{30}O_{15}$	679.1657 [M+H]+	679.1647 [M+H]+	-1.54	phenylethanoid glycosides	-	↑***
102	6.492	fisetin	$C_{15}H_{10}O_6$	287.0550 [M+H]+	287.0552 [M+H]+	0.646	flavonoids	-	↑***
103	6.545	scoparone	$C_{11}H_{10}O_4$	207.0652 [M+H]+	207.0651 [M+H]+	-0.41	coumarins	-	-
104	6.629	isochlorogenic acid B	$C_{25}H_{24}O_{12}$	517.1341 [M+H]+	517.1337 [M+H]+	-0.68	phenylethanoid glycosides	-	↑***
105	6.669	senkyunolide I/H 1	$C_{12}H_{16}O_4$	247.0941 [M+Na]+	247.0939 [M+Na]+	-0.73	phthalide monomers	-	↓***
106	6.823	(3S,3aR,10R)-(-)-10-hydroxysedanolide	$C_{12}H_{18}O_3$	211.1329 [M+H]+	211.1332 [M+H]+	1.558	phthalide monomers	-	↑***

107	6.912	(3Z)-3-butylidene-4,5-dihydro-6,7-dihydroxy-1(3H)-isobenzofuranone	$C_{12}H_{14}O_4$	223.0965 $[M+H]^+$	223.0962 $[M+H]^+$	-1.28	phthalide monomers	-	↓***
108	6.930	(3R)-3-butyl-3,6,7-trihydroxy-1(3H)-isobenzofuranone	$C_{12}H_{14}O_5$	239.0914 $[M+H]^+$	239.0914 $[M+H]^+$	0	phthalide monomers	-	↓***
109	6.96	chuanxiongnolide R2	$C_{12}H_{18}O_4$	227.1278 $[M+H]^+$	227.1275 $[M+H]^+$	-1.26	phthalide monomers	↓***	↓***
110	6.963	senkyunolide I/H 2	$C_{12}H_{16}O_4$	247.0941 $[M+Na]^+$	247.094 $[M+Na]^+$	-0.32	phthalide monomers	-	↓***
111	6.968	3,4,5-trihydroxy-6-(hydroxymethyl) oxan-2-yl 2-(prop-1-en-2-yl)-2,3-dihydro-1-benzofuran-5-carboxylate	$C_{18}H_{22}O_8$	367.1387 $[M+H]^+$	367.1387 $[M+H]^+$	-0.12	others	↑***	↓***
112	7.291	3-carboxyethyl-phthalide	$C_{12}H_{18}O_2$	195.1380 $[M+H]^+$	195.138 $[M+H]^+$	0.223	phthalide monomers	-	↑***
113	7.441	robinetin	$C_{15}H_{10}O_7$	303.0499 $[M+H]^+$	303.0498 $[M+H]^+$	-0.43	flavonoids	-	↑***
114	7.529	(Z)-3-butylidene-4,5,6-trihydroxy-1(3H)-Isobenzofuranone	$C_{12}H_{12}O_5$	237.0758 $[M+H]^+$	237.0755 $[M+H]^+$	-1.05	phthalide monomers	-	↓***
115	8.029	3-butyl-4,7-dihydroxyphthalide	$C_{12}H_{14}O_4$	223.0965 $[M+H]^+$	223.0964 $[M+H]^+$	-0.38	phthalide monomers	-	↓***
116	8.284	(3S,3aR,4R)-4-hydroxy-sedanolide	$C_{12}H_{18}O_3$	211.1329 $[M+H]^+$	211.1327 $[M+H]^+$	-0.81	phthalide monomers	-	↓***
117	8.305	(R)-3-butyl-7-hydroxy-3-methoxyphthalide	$C_{13}H_{16}O_4$	237.1121 $[M+H]^+$	237.1119 $[M+H]^+$	-0.99	phthalide monomers	↑***	-
118	8.427	8-{3-oxo-2-[(2E)-2-penten-1-yl]-1-cyclopenten-1-yl}octanoic acid	$C_{18}H_{28}O_3$	293.2111 $[M+H]^+$	293.2105 $[M+H]^+$	-2.12	long-chain fatty acids and its eaters	↑*	↑***
119	8.471	psoralen	$C_{11}H_6O_3$	187.0390 $[M+H]^+$	187.0388 $[M+H]^+$	-0.91	coumarins	-	↓***
120	8.571	cyanidin	$C_{15}H_{10}O_6$	287.0550 $[M+H]^+$	287.0549 $[M+H]^+$	-0.4	flavonoids	-	↑***
121	8.579	2-hydroxyphenyl valerate	$C_{11}H_{14}O_3$	195.1016 $[M+H]^+$	195.1016 $[M+H]^+$	0.15	aromatic acids and its esters	-	↓***
122	8.743	(3S,3aR,6S)-6-hydroxy-sedanolide	$C_{12}H_{18}O_3$	211.1329 $[M+H]^+$	211.1332 $[M+H]^+$	1.558	phthalide monomers	-	↓***
123	8.803	bergapten	$C_{12}H_8O_4$	217.0495 $[M+H]^+$	217.0492 $[M+H]^+$	-1.54	coumarins	-	↑***
124	8.852	3-(3-hydroxybutyl)-1(3H)-isobenzofuranone	$C_{12}H_{14}O_3$	207.1016 $[M+H]^+$	207.1015 $[M+H]^+$	-0.34	phthalide monomers	-	↓***
125	8.94	(3Z)-4,5,6,7-	$C_{11}H_{14}O_2$	179.1067	179.1065	-0.87	phthalide	-	↓***

		tetrahydro-3-propylidene-1(3H)-isobenzofuranone		$[M+H]^+$	$[M+H]^+$		monomers		
126	8.948	3-butyl-6,7-dihydroxyphthalide	$C_{12}H_{14}O_4$	223.0965 $[M+H]^+$	223.0964 $[M+H]^+$	-0.38	phthalide monomers	-	↓***
127	9.122	senkyunolide D	$C_{12}H_{14}O_4$	223.0965 $[M+H]^+$	223.0963 $[M+H]^+$	-0.83	phthalide monomers	↓	↓***
128	9.127	senkyunolide K	$C_{12}H_{16}O_3$	209.1172 $[M+H]^+$	209.117 $[M+H]^+$	-1.06	phthalide monomers	-	-
129	9.327	5-hydroxyphthalide	$C_{12}H_{14}O_3$	207.1016 $[M+H]^+$	207.1013 $[M+H]^+$	-1.31	phthalide monomers	-	↓***
130	9.337	senkyunolide G	$C_{12}H_{16}O_3$	209.1172 $[M+H]^+$	209.1172 $[M+H]^+$	-0.1	phthalide monomers	-	↓***
131	9.542	senkyunolide F	$C_{12}H_{14}O_3$	207.1016 $[M+H]^+$	207.1013 $[M+H]^+$	-1.31	phthalide monomers	-	↓***
132	9.552	ethyl ferulate	$C_{12}H_{14}O_4$	223.0965 $[M+H]^+$	223.0962 $[M+H]^+$	-1.28	coumarins	↓	↓***
133	9.669	(3R,3aR)-3a,4,5,6-tetrahydro-3-propyl-1(3H)-isobenzofuranone	$C_{11}H_{16}O_2$	181.1223 $[M+H]^+$	181.1221 $[M+H]^+$	-1.14	phthalide monomers	-	↑***
134	9.777	(4Z)-4-butylidenehexahydrooxireno[e]isobenzofuran-6(1aH)-one	$C_{12}H_{16}O_3$	209.1172 $[M+H]^+$	209.1172 $[M+H]^+$	-0.1	phthalide monomers	↓	↓***
135	9.78	senkyunolide E	$C_{12}H_{12}O_3$	205.0859 $[M+H]^+$	205.0856 $[M+H]^+$	-1.56	phthalide monomers	-	-
136	9.853	(E)-3-butylidene-4,5,6-trihydroxy-1(3H)-Isobenzofuranone	$C_{12}H_{12}O_5$	237.0758 $[M+H]^+$	237.0756 $[M+H]^+$	-0.63	phthalide monomers	-	↓*
137	9.88	4-hydroxy-3-butylphthalide	$C_{12}H_{14}O_3$	207.1016 $[M+H]^+$	207.1015 $[M+H]^+$	-0.34	phthalide monomers	-	↓***
138	9.988	acetophenone	C_8H_8O	121.0648 $[M+H]^+$	121.0649 $[M+H]^+$	0.896	others	-	-
139	10.176	butyl benzoate	$C_{11}H_{14}O_2$	179.1067 $[M+H]^+$	179.1064 $[M+H]^+$	-1.43	aromatic acids and its esters	-	↓***
140	10.263	6,7-exoxyligustilide	$C_{12}H_{14}O_3$	207.1016 $[M+H]^+$	207.1013 $[M+H]^+$	-1.31	phthalide monomers	-	↓***
141	10.344	senkyunolide C	$C_{12}H_{12}O_3$	205.0859 $[M+H]^+$	205.0857 $[M+H]^+$	-1.08	phthalide monomers	-	-
142	10.595	senkyunolide M/Q 1	$C_{16}H_{22}O_4$	279.1591 $[M+H]^+$	279.1586 $[M+H]^+$	-1.74	phthalide monomers	-	-
143	10.602	senkyunolide L	$C_{12}H_{15}O_3Cl$	243.0782 $[M+H]^+$	243.0781 $[M+H]^+$	-0.61	phthalide monomers	-	-
144	10.717	3-coumaric acid	$C_9H_8O_3$	163.0390 $[M-H]^-$	163.0394 $[M-H]^-$	2.634	coumarins	-	↓***
145	10.784	4-hydroxy-butylidenephthalide	$C_{12}H_{12}O_3$	205.0859 $[M+H]^+$	205.0858 $[M+H]^+$	-0.59	phthalide monomers	-	↓***
146	10.902	dimethyl Phthalate	$C_{10}H_{10}O_4$	195.0652 $[M+H]^+$	195.0649 $[M+H]^+$	-1.46	aromatic acids and its esters	-	↓***
147	11.254	senkyunolide M/Q 2	$C_{16}H_{22}O_4$	279.1591 $[M+H]^+$	279.1589 $[M+H]^+$	-0.67	phthalide monomers	↓	↓***
148	11.297	senkyunolide B	$C_{12}H_{12}O_3$	205.0859 $[M+H]^+$	205.0859 $[M+H]^+$	-0.1	phthalide monomers	-	↓***
149	11.576	3-butyl-4,5-dihydro-7-hydroxy-6-(1-	$C_{16}H_{22}O_4$	279.1591 $[M+H]^+$	279.1586 $[M+H]^+$	-1.74	phthalide monomers	-	↓***

		oxobutyl)-1(3H)-isobenzofuranone							
150	11.676	(Z)-propylidenephthalide	$C_{11}H_{12}O_2$	177.0910 $[M+H]^+$	177.0909 $[M+H]^+$	-0.6	phthalide monomers	-	↓***
151	11.746	senkyunolide A	$C_{12}H_{16}O_2$	193.1223 $[M+H]^+$	193.1221 $[M+H]^+$	-1.07	phthalide monomers	-	↓***
152	11.915	chuanxiongnolide L5 or its isomer 1	$C_{24}H_{30}O_6$	415.2115 $[M+H]^+$	415.2109 $[M+H]^+$	-1.48	phthalide dimers	-	↑***
153	11.958	3-butyl-5,6-dihydro-4H-isobenzofuran-1-one	$C_{12}H_{16}O_2$	193.1223 $[M+H]^+$	193.1222 $[M+H]^+$	-0.55	phthalide monomers	-	↓***
154	12.072	phthaldialdehyde	$C_8H_6O_2$	135.0441 $[M+H]^+$	135.0440 $[M+H]^+$	-0.41	others	-	↓***
155	12.073	butylphthalide	$C_{12}H_{14}O_2$	191.1067 $[M+H]^+$	191.1065 $[M+H]^+$	-0.82	phthalide monomers	-	↓***
156	12.278	neocnidilide	$C_{12}H_{18}O_2$	195.1380 $[M+H]^+$	195.138 $[M+H]^+$	0.223	phthalide monomers	-	↓***
157	12.601	(3Z)-3-butylidene-4-methoxy-1(3H)-isobenzofuranone	$C_{13}H_{14}O_3$	219.1016 $[M+H]^+$	219.1014 $[M+H]^+$	-0.78	phthalide monomers	-	-
158	12.816	E-ligustilide	$C_{12}H_{14}O_2$	191.1067 $[M+H]^+$	191.1064 $[M+H]^+$	-1.34	phthalide monomers	-	↓***
159	12.926	cnidilide	$C_{12}H_{18}O_2$	195.1380 $[M+H]^+$	195.1377 $[M+H]^+$	-1.31	phthalide monomers	-	↓***
160	12.967	E-butenylphthalide	$C_{12}H_{12}O_2$	189.0910 $[M+H]^+$	189.0909 $[M+H]^+$	-0.56	phthalide monomers	-	↓***
161	13.105	4-methyl-6-phenyl-5,6-dihydro-2H-pyran-2-one	$C_{12}H_{12}O_2$	189.0910 $[M+H]^+$	189.0909 $[M+H]^+$	-0.56	others	-	↓***
162	13.11	α-linolenic acid	$C_{18}H_{30}O_2$	279.2319 $[M+H]^+$	279.2316 $[M+H]^+$	-0.92	long-chain fatty acids and its eaters	↓**	-
163	13.115	chuanxiongnolide L5 or its isomer 2	$C_{24}H_{30}O_6$	415.2115 $[M+H]^+$	415.2111 $[M+H]^+$	-1	phthalide dimers	-	-
165	13.304	Z-ligustilide	$C_{12}H_{14}O_2$	191.1067 $[M+H]^+$	191.1064 $[M+H]^+$	-1.34	phthalide monomers	-	↓***
164	13.332	isocnidilide	$C_{12}H_{18}O_2$	195.1380 $[M+H]^+$	195.1376 $[M+H]^+$	-1.83	phthalide monomers	-	
166	13.684	chuanxiongnolide A/B	$C_{24}H_{28}O_5$	397.2010 $[M+H]^+$	397.2004 $[M+H]^+$	-1.39	phthalide dimers	-	↓***
167	13.715	Z-butenylphthalide	$C_{12}H_{12}O_2$	189.0910 $[M+H]^+$	189.0908 $[M+H]^+$	-1.09	phthalide monomers	-	↓***
168	13.764	chuanxiongnolide L5 or its isomer 3	$C_{24}H_{30}O_6$	415.2115 $[M+H]^+$	415.2106 $[M+H]^+$	-2.2	phthalide dimers	-	-
169	13.817	CV-1	$C_{24}H_{30}O_5$	399.2166 $[M+H]^+$	399.2162 $[M+H]^+$	-1	phthalide dimers	-	↓***
170	13.953	demethywallichilide	$C_{24}H_{30}O_5$	399.2166 $[M+H]^+$	399.2165 $[M+H]^+$	-0.25	phthalide dimers	-	-
171	13.987	3-butylhexahydro-1(3H)-isobenzofuranone	$C_{12}H_{20}O_2$	197.1536 $[M+H]^+$	197.1537 $[M+H]^+$	0.475	phthalide monomers	-	-
172	14.339	CII-1	$C_{24}H_{28}O_5$	397.2010 $[M+H]^+$	397.2005 $[M+H]^+$	-1.13	phthalide dimers	-	↓***
173	14.919	2-aminooctadec-4-yne-1,3-diol	$C_{18}H_{35}NO_2$	298.2741 $[M+H]^+$	298.2738 $[M+H]^+$	-0.86	long-chain fatty acids and its eaters	-	↓**
174	15.59	DI-1	$C_{24}H_{30}O_4$	383.2217	383.2213	-1.01	phthalide	-	↓***

	3			$[M+H]^+$	$[M+H]^+$		dimers		
175	15.728	12-oxo phytodienoic Acid	$C_{18}H_{28}O_3$	293.2111 $[M+H]^+$	293.2104 $[M+H]^+$	-2.46	long-chain fatty acids and its eaters	-	↑***
176	16.222	9S,13R-12-oxophytodienoic acid	$C_{18}H_{28}O_3$	293.2111 $[M+H]^+$	293.2105 $[M+H]^+$	-2.12	long-chain fatty acids and its eaters	-	↑***
177	16.839	3,8-dihydro-diligustilide	$C_{24}H_{32}O_4$	385.2373 $[M+H]^+$	385.2367 $[M+H]^+$	-1.65	phthalide dimers	-	-
178	16.84	riligustilide	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2054 $[M+H]^+$	-1.67	phthalide dimers	-	-
179	17.005	Z,Z'-3,3',8,8'-diligustilide	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2056 $[M+H]^+$	-1.14	phthalide dimers	-	↓***
180	17.309	(Z)-3,8-dihydro-6,6',7,3'a-diligustilide	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2211 $[M+H]^+$	-1.53	phthalide dimers	-	↓***
181	17.662	3,8-dihydro-levistilide A	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2213 $[M+H]^+$	-1.01	phthalide dimers	-	-
182	17.834	9-oxo-ODE or isomer 1	$C_{18}H_{30}O_3$	295.2268 $[M+H]^+$	295.2264 $[M+H]^+$	-1.26	long-chain fatty acids and its eaters	-	-
183	18.169	9-oxo-ODE or isomer 2	$C_{18}H_{30}O_3$	295.2268 $[M+H]^+$	295.2266 $[M+H]^+$	-0.58	long-chain fatty acids and its eaters	-	↑***
184	18.239	DI-2	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2214 $[M+H]^+$	-0.75	phthalide dimers	-	↑***
185	18.479	DII-1	$C_{24}H_{30}O_5$	399.2166 $[M+H]^+$	399.216 $[M+H]^+$	-1.5	phthalide dimers	-	↓***
186	18.511	9-oxo-ODE or isomer 3	$C_{18}H_{30}O_3$	295.2268 $[M+H]^+$	295.2265 $[M+H]^+$	-0.92	long-chain fatty acids and its eaters	-	↑***
187	18.632	senkyunolide P	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2211 $[M+H]^+$	-1.53	phthalide dimers	-	↓***
188	18.8	angelicolide	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2058 $[M+H]^+$	-0.62	phthalide dimers	-	-
189	18.827	chuanxiongdiolide A	$C_{24}H_{32}O_4$	385.2373 $[M+H]^+$	385.2369 $[M+H]^+$	-1.13	phthalide dimers	-	↓***
190	18.866	BII-1	$C_{24}H_{26}O_5$	395.1853 $[M+H]^+$	395.1848 $[M+H]^+$	-1.27	phthalide dimers	-	↓***
191	19.034	9-oxo-ODE or isomer 4	$C_{18}H_{30}O_3$	295.2268 $[M+H]^+$	295.2266 $[M+H]^+$	-0.58	long-chain fatty acids and its eaters	-	↑***
192	19.133	wallichilide	$C_{25}H_{32}O_5$	413.2323 $[M+H]^+$	413.2316 $[M+H]^+$	-1.57	phthalide dimers	↑**	↓***
193	19.138	4,5-dehydro-diligustilide	$C_{24}H_{26}O_4$	379.1904 $[M+H]^+$	379.1899 $[M+H]^+$	-1.28	phthalide dimers	-	↑***
194	19.27	levistolide B	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2054 $[M+H]^+$	-1.67	phthalide dimers	-	-
195	19.336	methyl ester derived from angeolide	$C_{25}H_{32}O_5$	413.2323 $[M+H]^+$	413.2316 $[M+H]^+$	-1.57	phthalide dimers	↑*	↓***
196	19.374	senkyunolide O	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2053 $[M+H]^+$	-1.93	phthalide dimers	-	↑***
197	19.396	levistolide A	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2056 $[M+H]^+$	-1.14	phthalide dimers	-	-
198	19.667	DI-3	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2213 $[M+H]^+$	-1.01	phthalide dimers	-	↑***
199	19.796	DII-2	$C_{24}H_{30}O_5$	399.2166 $[M+H]^+$	399.2166 $[M+H]^+$	-0	phthalide dimers	↑***	↑***
200	19.879	DI-4	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2211 $[M+H]^+$	-1.53	phthalide dimers	-	↑***
201	20.011	(3Z)-(3aR,6S,3'R,8S)-3a.8',6.3'-diligustilide	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2061 $[M+H]^+$	0.168	phthalide dimers	-	↑***
202	20.106	FII-1	$C_{24}H_{32}O_5$	401.2323 $[M+H]^+$	401.2315 $[M+H]^+$	-1.87	phthalide dimers	↓***	↑***
203	20.115	DI-5	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2212 $[M+H]^+$	-1.27	phthalide dimers	-	↑***

204	20.382	tokinolide A	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.206 $[M+H]^+$	-0.09	phthalide dimers	-	↑***
205	20.449	chaxiongnolide F	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2215 $[M+H]^+$	-0.49	phthalide dimers	-	↑***
206	20.559	tokiaerialide	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2054 $[M+H]^+$	-1.67	phthalide dimers	-	↑***
207	20.674	CI-1	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2057 $[M+H]^+$	-0.88	phthalide dimers	-	↑***
208	20.826	all-cis-4,7,10,13,16-docosapentaenoic acid	$C_{22}H_{34}O_2$	331.2632 $[M+H]^+$	331.2629 $[M+H]^+$	-0.78	long-chain fatty acids and its eaters	-	↓***
209	20.887	chaxiongnolide D	$C_{24}H_{32}O_4$	385.2373 $[M+H]^+$	385.2375 $[M+H]^+$	0.426	phthalide dimers	↓**	↑***
210	20.922	neodiligustilide	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2058 $[M+H]^+$	-0.62	phthalide dimers	-	↑***
211	21.069	DI-6	$C_{24}H_{30}O_4$	383.2217 $[M+H]^+$	383.2215 $[M+H]^+$	-0.49	phthalide dimers	-	-
212	21.206	palmitoyl ethanolamide	$C_{18}H_{37}NO_2$	300.2897 $[M+H]^+$	300.2892 $[M+H]^+$	-1.68	long-chain fatty acids and its eaters	-	-
213	21.239	(S)-1-linoleoyl glycerol	$C_{21}H_{38}O_4$	355.2843 $[M+H]^+$	355.2843 $[M+H]^+$	0.039	long-chain fatty acids and its eaters	↓***	-
214	21.247	pinolenic acid	$C_{18}H_{30}O_2$	279.2319 $[M+H]^+$	279.2317 $[M+H]^+$	-0.56	long-chain fatty acids and its eaters	↓***	↓***
215	21.421	triligustilides A/B/C or its isomer 1	$C_{36}H_{42}O_6$	588.3320 $[M+NH_4]^+$	588.3318 $[M+NH_4]^+$	-0.28	phthalide trimers	-	↑***
216	21.473	chaxiongnolide E	$C_{24}H_{32}O_4$	385.2373 $[M+H]^+$	385.2379 $[M+H]^+$	1.464	phthalide dimers	-	↑***
217	21.539	(R)-1-linoleoyl glycerol	$C_{21}H_{38}O_4$	355.2843 $[M+H]^+$	355.2838 $[M+H]^+$	-1.37	long-chain fatty acids and its eaters	-	-
218	21.653	oleoyl ethanolamide	$C_{20}H_{39}NO_2$	326.3054 $[M+H]^+$	326.3051 $[M+H]^+$	-0.78	long-chain fatty acids and its eaters		↓***
219	21.766	16-hydroxyhexadecanoic acid	$C_{16}H_{32}O_3$	271.2268 $[M+H]^+$	271.2279 $[M+H]^+$	4.161	long-chain fatty acids and its eaters	-	-
220	21.866	triligustilides A/B/C or its isomer 2	$C_{36}H_{42}O_6$	588.3320 $[M+NH_4]^+$	588.3314 $[M+NH_4]^+$	-0.96	phthalide trimers	-	↑***
221	21.872	Z,Z'-3,3'a,7,7'a-diligustilide	$C_{24}H_{28}O_4$	381.2060 $[M+H]^+$	381.2058 $[M+H]^+$	-0.62	phthalide dimers	-	↑***
222	22.071	chuanxiongdiolide R5	$C_{24}H_{32}O_4$	385.2373 $[M+H]^+$	385.2370 $[M+H]^+$	-0.87	phthalide dimers	↓**	↑***
223	22.152	triligustilides A/B/C or its isomer 3	$C_{36}H_{42}O_6$	588.3320 $[M+NH_4]^+$	588.3315 $[M+NH_4]^+$	-0.79	phthalide trimers	-	↑***
224	22.156	hexadecanamide	$C_{16}H_{33}NO$	256.2635 $[M+H]^+$	256.2632 $[M+H]^+$	-1.14	long-chain fatty acids and its eaters	-	↑***
225	22.198	palmitoleic acid	$C_{16}H_{30}O_2$	255.2319 $[M+H]^+$	255.2316 $[M+H]^+$	-1.01	long-chain fatty acids and its eaters	-	-
226	22.532	oleamide	$C_{18}H_{35}NO$	282.2791 $[M+H]^+$	282.2789 $[M+H]^+$	-0.85	long-chain fatty acids and its eaters	-	↑***
227	22.747	triligustilides A/B/C or its isomer 4	$C_{36}H_{42}O_6$	588.3320 $[M+NH_4]^+$	588.3314 $[M+NH_4]^+$	-0.96	phthalide trimers	-	↑***
228	23.141	triligustilides A/B/C or its isomer 5	$C_{36}H_{42}O_6$	588.3320 $[M+NH_4]^+$	588.3316 $[M+NH_4]^+$	-0.62	phthalide trimers	-	↑***
229	24.584	lupenone	$C_{30}H_{48}O$	425.3778 $[M+H]^+$	425.3777 $[M+H]^+$	-0.22	others	-	↑***
230	24.62	docosahexaenoi	$C_{22}H_{32}O_2$	329.2475	329.2476	0.283	long-chain fatty	↑	↑

		c acid		$[M+H]^+$	$[M+H]^+$		acids and its eaters		
231	25.679	γ-linolenic acid ethyl ester	$C_{20}H_{34}O_2$	307.2632 $[M+H]^+$	307.263 $[M+H]^+$	-0.51	long-chain fatty acids and its eaters	-	↓***
232	27.595	α-eleostearic acid	$C_{18}H_{30}O_2$	279.2319 $[M+H]^+$	279.2317 $[M+H]^+$	-0.56	long-chain fatty acids and its eaters	-	↓***
233	27.829	erucamide	$C_{22}H_{43}NO$	338.3417 $[M+H]^+$	338.3415 $[M+H]^+$	-0.71	long-chain fatty acids and its eaters	-	-
234	28.005	β-eleostearic acid	$C_{18}H_{30}O_2$	279.2319 $[M+H]^+$	279.2318 $[M+H]^+$	-0.2	long-chain fatty acids and its eaters	-	↓***

Notes: Compared with the content of compounds in rhizomes, "↑" means up regulation and "↓" means down regulation; n = 7;*p < 0.05, **p < 0.01, ***p < 0.001.

Table S2 Compounds were characterized in different parts of CX by GC-MS Analysis

Peak	RT (min)	Mass	Match Score	Name	CAS	Class of compound	X vs. G	Y vs. G
1	4.257	136	93	*α*-thujene	002867-05-2	monoterpenes	↑**	-
2	4.399	136	94	(+)-*α*-pinene	000080-56-8	monoterpenes	↑	-
3	5.14	136	96	sabinene	003387-41-5	monoterpenes	↑**	-
4	5.222	136	90	*β*-pinene	000127-91-3	monoterpenes	↑**	-
5	5.452	136	97	*β*-myrcene	000123-35-3	monoterpenes	↑**	↓**
6	6.04	136	96	(+)-2-carene	1000149-94-6	monoterpenes	↑**	↓**
7	6.222	134	97	*p*-cymene	000099-87-6	aromatics	↑**	↓**
8	6.322	136	87	*β*-terpinene	000099-84-3	monoterpenes	↑**	↑*
9	7.016	136	96	*γ*-terpinene	000099-85-4	monoterpenes	↑***	↓*
10	7.745	136	98	*α*-terpinolene	000586-62-9	monoterpenes	↑**	↓*
11	9.522	150	91	5-pentylcyclohexa-1,3-diene	056318-84-4	olefins	↑***	↓**
12	10.075	154	97	(-)-terpinen-4-ol	020126-76-5	monoterpenes	↑***	↓***
13	10.281	150	91	*p*-cymen-8-ol	005208-37-7	alcohols	-	↓***
14	13.121	184	97	tridecane	000629-50-5	alkanes	↑***	
15	13.533	150	90	2-methoxy-4-vinylphenol	007786-61-0	aromatics	-	↓***
16	13.992	136	91	1,5,5-trimethyl-6-methylene-cyclohexene	000514-95-4	monoterpenes	-	↓***
17	14.316	150	91	1,4-cyclohexadiene-1,2-dicarboxylic anhydride	004773-89-1	anhydrides	-	↑
18	14.374	162	94	valerophenone	001009-14-9	ketones	↓***	↓***
19	14.939	170	90	(*Z*)-1-methoxy-4-decene	1000333-84-8	ethers	-	↓***
20	15.057	204	91	(-)-*β*-elemene	000515-13-9	sesquiterpenes	-	-
21	15.257	178	96	methyleugenol	000093-15-2	ethers	↓***	↓***
22	15.292	184	90	dodecanal	000112-54-9	aldehyde	↑***	-
23	15.474	204	94	(-)-*α*-cedrene	000546-28-1	sesquiterpenes	↑***	-
24	15.569	204	99	caryophyllene	000087-44-5	sesquiterpenes	↑*	↑***
25	15.651	204	90	himachalene-1,4-diene	1000412-94-8	sesquiterpenes	↓***	↓***
26	15.768	204	98	*γ*-elemene	029873-99-2	sesquiterpenes	-	-
27	16.104	204	96	(*E*)-β-eamesene	018794-84-8	sesquiterpenes	-	↑***
28	16.145	204	96	humulene	006753-98-6	sesquiterpenes	-	↓***
29	16.416	204	91	(3*R*,3a*S*,7*S*,8a*R*)-3,8,8-trimethyl-6-methyleneoctahydro-1H-3a,7-methanoazulene	000546-28-1	sesquiterpenes	-	↓***
30	16.468	204	94	eudesma-4(14),7(11)-diene	000515-17-3	sesquiterpenes	-	-
31	16.58	204	99	germacrene D	023986-74-5	sesquiterpenes	↑***	↑***
32	16.68	204	99	*β*-selinene	017066-67-0	sesquiterpenes	↓***	-
33	16.804	204	95	*α*-selinene	000473-13-2	sesquiterpenes	-	-
34	16.892	204	91	*α*-farnesene	000502-61-4	sesquiterpenes	-	↑***
35	17.063	204	98	*α*-amorphene	000483-75-0	sesquiterpenes	-	-
36	17.18	204	98	*δ*-amorphene	016729-01-4	sesquiterpenes	↓***	↑***
37	17.704	204	96	germacrene B	015423-57-1	sesquiterpenes	-	↑***
38	17.762	220	99	ylangenol	115728-41-1	sesquiterpenes	-	↑***
39	18.01	220	99	spathulenol	006750-60-3	sesquiterpenes	↓***	-
40	18.086	220	98	caryophyllene oxide	001139-30-6	sesquiterpenes	↓***	↑***
41	18.268	222	91	carotol	000465-28-1	sesquiterpenes	-	-
42	18.321	194	90	1,13-tetradecadiene	021964-49-8	olefins	-	-

43	18.362	222	93	cedrol	000077-53-2	sesquiterpenes	↓***	↓***
44	18.78	196	98	hexahydro-3-butylphthalide	003553-34-2	phthalides	-	-
45	18.986	190	94	3-n-butylphthalide	006066-49-5	phthalides	-	-
46	19.133	196	96	cyclotetradecane	000295-17-0	alkanes	-	↓***
47	19.268	188	98	*Z*-butylidenephthalide	072917-31-8	phthalides	-	-
48	19.339	192	90	N,N'-diacetyl-1,4-phenylenediamine	000140-50-1	amide	↓***	↓***
49	19.398	220	92	1R,7*S*,*E*)-7-isopropyl-4,10-dimethylenecyclodec-5-enol	081968-62-9	sesquiterpenes	-	↑***
50	20.06	192	98	senkyunolide A	062006-39-7	phthalides	-	↓***
51	20.22	190	99	*Z*-ligustilide	081944-08-3	phthalides	-	-
52	20.333	224	98	cetene	000629-73-2	olefins	-	↓***
53	20.598	206	97	3-pentyl-4,5-dihydroisobenzofuran-1(3H)-one	128575-99-5	phthalides	-	-
54	20.768	190	99	*E*-ligustilide	081944-09-4	phthalides	-	
55	20.98	278	99	neophytadiene	000504-96-1	olefins	-	↑***
56	21.056	268	90	6,10,14-trimethylpentadecan-2-one	000502-69-2	ketones	-	↑***
57	21.239	242	95	pentadecanoic acid	001002-84-2	fatty acid and its esters	-	↑***
58	21.433	224	99	cyclohexadecane	000295-65-8	alkanes	-	↓***
59	21.603	264	91	linolenyl alcohol	000506-44-5	alcohols	-	↑**
60	21.892	270	99	methyl palmitate	000112-39-0	fatty acid and its esters	-	↑***
61	22.297	256	99	n-hexadecanoic acid	000057-10-3	fatty acid and its esters	↓***	↑***
62	22.345	278	87	dibutyl phthalate	1000356-78-4	anhydrides	↑***	↑
63	22.574	284	98	ethyl palmitate	000628-97-7	fatty acid and its esters	↓***	-
64	22.621	282	99	eicosane	000112-95-8	alkanes	-	↑***
65	23.068	224	99	senkyunolide H/I	094596-27-7	phthalides	↑***	↑*
66	23.58	296	99	heneicosane	000629-94-7	alkanes	-	↑***
67	23.627	296	99	trans-13-octadecenoic acid, methyl ester	1000333-61-3	fatty acid and its esters	-	↑***
68	23.762	296	90	phytol	000150-86-7	alcohols	-	↑*
69	23.968	280	99	linoleic acid	000060-33-3	fatty acid and its esters	-	↑***
70	24.191	308	99	linoleic acid ethyl ester	000544-35-4	fatty acid and its esters	↓***	↑***
71	24.244	310	95	(*E*)-9-octadecenoic acid ethyl ester	006114-18-7	fatty acid and its esters	-	↑***
72	24.503	310	94	docosane	000629-97-0	alkanes	↑***	↑***
73	25.38	282	96	heptadecane	000112-95-8	alkanes	↑***	↑***
74	25.891	336	93	butyl 9,12-octadecadienoate	1000336-54-1	fatty acid and its esters	-	↑***
75	26.221	338	99	tetracosane	000646-31-1	alkanes	-	↑***

Notes: Compared with the content of compounds in rhizomes, "↑" means up regulation and "↓" means down regulation; n = 7; *p < 0.05, **p < 0.01, ***p < 0.001.

Table S3 Formula list of phthalide monomers

substituent	D = 7	D = 6	D = 5	D = 4	D = 3
none	$C_{12}H_{12}O_2$*	$C_{12}H_{14}O_2$*	$C_{12}H_{16}O_2$*	$C_{12}H_{18}O_2$*	$C_{12}H_{12}O_2$*
1 OH	$C_{12}H_{12}O_3$*	$C_{12}H_{14}O_3$*	$C_{12}H_{16}O_3$*	$C_{12}H_{18}O_3$*	
2 OH	$C_{12}H_{12}O_4$*	$C_{12}H_{14}O_4$*	$C_{12}H_{16}O_4$*	$C_{12}H_{18}O_4$*	
3 OH	$C_{12}H_{12}O_5$	$C_{12}H_{14}O_5$	$C_{12}H_{16}O_5$*	$C_{12}H_{18}O_5$*	
1 CH_3	$C_{13}H_{14}O_2$*	$C_{13}H_{16}O_2$*	$C_{13}H_{18}O_2$	$C_{13}H_{20}O_2$	
1 OCH_3	$C_{13}H_{14}O_3$	$C_{13}H_{16}O_3$*	$C_{13}H_{18}O_3$*	$C_{13}H_{20}O_3$	
1 OH、1 OCH_3	$C_{13}H_{14}O_4$	$C_{13}H_{16}O_4$*	$C_{13}H_{18}O_4$	$C_{13}H_{20}O_4$*	
1 OH、1 OAc	$C_{14}H_{14}O_5$	$C_{14}H_{16}O_5$	$C_{14}H_{18}O_5$*	$C_{14}H_{20}O_5$*	
1 OH、1 COC_3H_7	$C_{16}H_{18}O_4$	$C_{16}H_{20}O_4$	$C_{16}H_{22}O_4$*	$C_{16}H_{24}O_4$*	
1 OH、1 =O	$C_{12}H_{10}O_3$	$C_{12}H_{12}O_3$	$C_{12}H_{14}O_3$*	$C_{12}H_{16}O_3$*	
1 OAng		$C_{17}H_{20}O_4$*			

D: degree of unsaturation; *: phthalides have been found

Table S4 Formula list of phthalide dimers

monomers units	I (no	II（1	III (2 OH)	IV (open	V (open

		substituent)	OH）		loop, CH_3OH)	loop, H_2O)
A	n-butylidenephthalide couple with n-butylidenephthalide	$C_{24}H_{24}O_4$*	$C_{24}H_{24}O_5$	$C_{24}H_{24}O_6$		
B	n-butylidenephthalide couple with ligustilide	$C_{24}H_{26}O_4$*	$C_{24}H_{26}O_5$	$C_{24}H_{26}O_6$	$C_{25}H_{30}O_5$*	$C_{24}H_{28}O_5$
C	ligustilide couple with ligustilide	$C_{24}H_{28}O_4$*	$C_{24}H_{28}O_5$*	$C_{24}H_{28}O_6$	$C_{25}H_{32}O_5$*	$C_{24}H_{30}O_5$*
D	ligustilide couple with senkyunolide A	$C_{24}H_{30}O_4$*	$C_{24}H_{30}O_5$*	$C_{24}H_{30}O_6$ *		
E	ligustilide couple with neosolactone	$C_{24}H_{32}O_4$*	$C_{24}H_{32}O_5$	$C_{24}H_{32}O_6$		
F	senkyunolide A couple with senkyunolide A	$C_{24}H_{32}O_4$*	$C_{24}H_{32}O_5$*	$C_{24}H_{32}O_6$		

*: phthalides have been found

Table S5 Polymerization sites of phthalide dimers

polymerization site		monomer unit-2					
		3a/7a	3/8	6/7	3a/6	4/7	7/7a
monomer unit-1	3a/7a	3a.3a′,7a.7a′ 3a.7a′,7a.3a′	3a.8′,7a.3′ 3a.3′,7a.8′	3a.6′,7a.7′ 3a.7′,7a.6′			3a.7a′,7a.7′ 3a.7′,7a.7a′
	3/8		3.3′,8.8′	3.7′,8.6′	3.3a′,8.6′ 3.6′,8.3a′		
	6/7			6.7′,7.6′ 6.6′,7.7′	6.6′,7.3a′ 6.3a′,7.6′	6.7′,7.4′	6.7′,7.7a′

Table S6 The percentage of compounds in volatile oils from different parts of CX

Compounds	Rhizome	Fibrous root	Stem and leaf
Sesquiterpenes	8.58%	5.80%	13.79%
Monoterpenes	2.29%	11.81%	0.19%
Phthalides	81.13%	75.32%	71.39%
Alkanes	0.43%	0.51%	4.00%
Olefins	0.89%	2.22%	1.52%
Aromatics	0.93%	1.43%	0.16%
Fatty acid and its esters	0.47%	0.16%	3.42%
Alcohols	0.09%	0.24%	0.01%
Ethers	0.23%	0.06%	0.00%
Anhydrides	0.13%	0.60%	0.04%
Ketones	0.41%	0.21%	0.04%
Aldehyde	0.00%	0.04%	0.00%
Amide	2.87%	1.01%	0.21%
Total	98.45%	99.44%	94.77%

Table S7 The normalized peak area of compounds in methanol extracts from different parts of CX

Compounds	Rhizome	Fibrous root	Stem and leaf
Amino acids	5.90	5.79	3.58
Nucleosides	1.90	1.27	1.06
Phthalide monomers	241.30	222.29	71.64
Phthalide dimers	14.65	17.60	17.94
Phthalide trimers	0.02	0.03	1.58
Phenolic acids	5.68	4.86	2.53
Flavonoids	0.00	0.00	0.77
Coumarins	0.19	0.30	0.22
Phenylethanoid glycosides	2.61	6.89	8.10
Aromatic acids and its esters	0.96	1.12	0.18
Short-chain fatty acids	3.33	4.96	1.74
Long-chain fatty acids and its eaters	3.24	2.75	2.91
Saccharides	10.13	13.76	10.54
Alkaloids	2.30	1.97	2.55
Others	1.14	0.98	0.84
Total	293.36	284.56	126.19