

การวิเคราะห์สารกำจัดศัตรูพืชตกค้างในแอปเปิลโดยใช้เทคนิค GC-(AEI)-MS/MS

ผู้จัดทำ : วรรณิกา พานนนท์

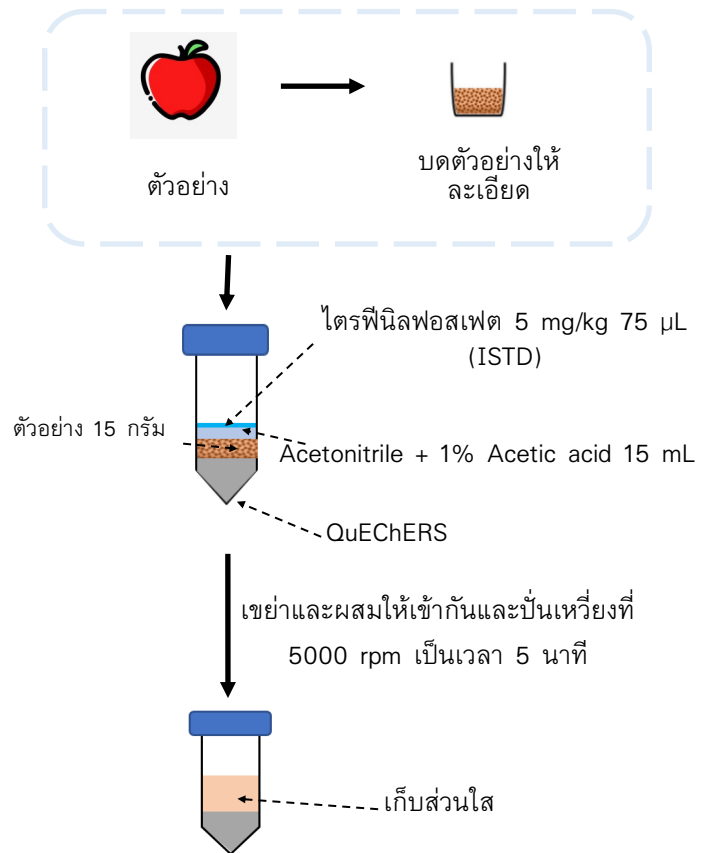
บทนำ

แอปเปิลเป็นผลไม้ที่นิยมรับประทานกันอย่างแพร่หลาย สามารถทานได้ทุกส่วน และยังเป็นผลไม้ที่มีความต้องการสูงในตลาดโลก แหล่งปลูกที่สำคัญจะเป็นทวีปเอเชีย โดยประเทศอินเดียเป็นผู้ผลิตแอปเปิลรายใหญ่ของโลก การปลูกแอปเปิลทำได้หลายวิธี หนึ่งในนั้นคือการปลูกแบบเชิงเดี่ยว ซึ่งการปลูกแอปเปิลแบบเชิงเดี่ยวมีความเสี่ยงต่อโรค เช่น โรคเชื้อราแบคทีเรีย และแมลงศัตรูพืชหลายชนิด โดยสวนผลไม้เชิงพาณิชย์หลายแห่ง มีการใช้สารเคมีทางการเกษตรเพื่อลดความเสียหายนี้รวมถึงรักษาคุณภาพของผลไม้ สุขภาพต้นไม้และมีผลผลิตสูง ปัจจุบัน สารเคมี 288 ชนิดจดทะเบียนภายใต้คณะกรรมการควบคุมและกำจัดแมลง Central Insecticide Board and Registration Committee (CIBRC) ของอินเดีย

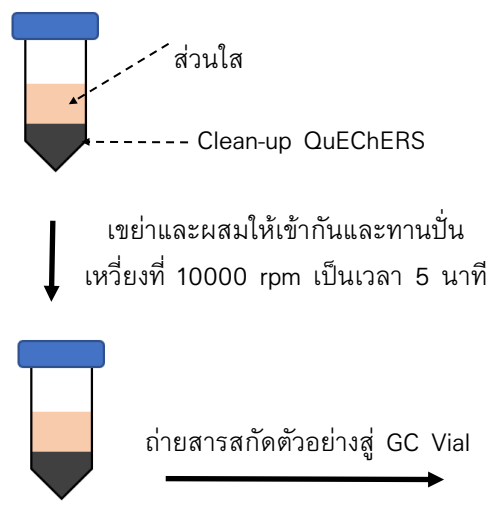
การใช้สารเคมีเกษตรอาจส่งผลให้เกิดสารกำจัดศัตรูพืชตกค้างในแอปเปิล ดังนั้นจึงจำเป็นต้องมีวิธีการวิเคราะห์ที่มีประสิทธิภาพซึ่งให้ผลลัพธ์ที่ถูกต้องแม่นยำ เพื่อให้สอดคล้องกับปริมาณสารตกค้างที่กฎหมายสามารถยอมรับได้ และสอดคล้องกับค่าปริมาณสารตกค้างสูงสุดที่ยอมให้พบได้ (Minimum Residue Limits - MRLs) ทางกฎหมาย EC และ (The Food Safety and Standards Authority of India- FSSAI) ได้ตั้งค่า MRL ในแอปเปิล MRL ต่ำสุดคือ 0.01 mg/kg

จุดมุ่งหมายของงาน นี้คือการพัฒนาและตรวจสอบวิธีการวิเคราะห์สารกำจัดศัตรูพืชหลายชนิด สำหรับการตรวจสอบสารกำจัดศัตรูพืชตกค้างในแอปเปิล โดยใช้วิธีการสกัดแบบ QuEChERS และวิเคราะห์ด้วยเทคนิค GC-MS/MS โดยแหล่งกำเนิดไอออนเป็นชนิด Advanced Electron Ionization (AEI) และประมวลผลข้อมูลโดยใช้โปรแกรม Chromeleon™ (Thermo Scientific™) ซึ่งเป็นวิธีการที่ได้รับการตรวจสอบว่าเป็นวิธีการตรวจสอบทางห้องปฏิบัติการ สอดคล้องกับแนวทางของ Analytical Quality Control and Method Validation Procedures for Pesticide Residues Analysis in Food and Feed (SANTE/11813/2017)


การเตรียมตัวอย่างด้วย QuEChERS



ขั้นตอนการเพิ่มความบริสุทธิ์



การวิเคราะห์ด้วย GC-MS/MS

| | |
|------------------------|--|
| Gas Chromatograph (GC) | TRACE™ 1300 Gas Chromatograph |
| Mass Spectrometer (MS) | TSQ™ Triple Quadrupole GC-MSMS System |
| Autosampler | TriPlus™ RSH LS Autosampler |
| Software | Chromeleon™  |

| TRACE™ 1300 Gas Chromatograph | |
|-------------------------------|--|
| Carrier Gas, Mode | He, constant flow, 1.2 (mL/min) |
| Injector Temp. | 250(°C) |
| Injection Mode | Splitless |
| Splitless Time | 2.0 min |
| Splitless Flow | 50 mL/min Gas saver flow 10mL/min after 10 min |
| Purge Flow | 5 mL/min |
| Column | TG-5SIL MS W/5 m safeguard(30m × 0.25mm i.d. × 0.25 µm) |
| Total Run Time | 34.9 min |
| GC oven program | 70°C(2 min) 25°C/min,90°C(1.5min) 25°C/min,180° 5°C/min,280° 10°C/min,300°(5min) |



รูปที่ 1 Thermo Scientific™ TSQ™ 9000 GC-MSMS

| TSQ™ 9000 Triple Quadrupole GC-MSMS | |
|-------------------------------------|---|
| Acquisition mode | Timed selected reaction monitoring (t-SRM mode) |
| MS transfer line temperature | 250°C |
| Ion Source temperature | 320°C |
| Ion source | AEI (Advanced Electron) |
| Ionization | Electron Ionization (EI) |
| Collision gas and pressure (psi) | Argon at 70 |
| Peak width (Da) | 0.7(both Q1 and Q3) |

| Working standard (µg/mL) | Volume taken from working standard (µL) | Extracted matrix (µL) | Final concentration (µg/kg) |
|--------------------------|---|-----------------------|-----------------------------|
| 1.000 | 50 | 950 | 0.050 |
| 0.500 | 50 | 950 | 0.025 |
| 0.200 | 50 | 950 | 0.01 |
| 0.100 | 50 | 950 | 0.005 |
| 0.050 | 50 | 950 | 0.0025 |
| 0.020 | 50 | 950 | 0.001 |
| 0.010 | 50 | 950 | 0.0005 |
| 0.005 | 50 | 950 | 0.00025 |
| 0.002 | 50 | 950 | 0.0001 |

ตารางที่ 1 การตั้งค่าสำหรับวิเคราะห์สารเคมีกำจัดศัตรูพืชชนิดต่างๆ

| Compound | RT | Parent Mass | Product Mass | CE |
|---------------------------|-------|-------------|--------------|----|
| 2,3,5,6-Tetrachloroanline | 10.35 | 230.8 | 157.9 | 18 |
| 2,3,5,6-Tetrachloroanline | 10.35 | 230.8 | 159.8 | 18 |
| 4,4'-Methoxychlor olefin | 19.32 | 308 | 238.2 | 12 |
| 4,4'-Methoxychlor olefin | 19.32 | 238.1 | 152.1 | 34 |
| Acetochlor | 12.94 | 223.1 | 132 | 20 |
| Acetochlor | 12.94 | 146.1 | 130 | 24 |
| Acrinathrin | 23.56 | 208.1 | 180.9 | 8 |
| Acrinathrin | 23.56 | 289 | 93.1 | 8 |
| Alachlor | 13.17 | 188.1 | 160.1 | 8 |
| Alachlor | 13.17 | 188.1 | 130 | 32 |
| Aldrin | 14.36 | 262.7 | 192.9 | 32 |
| Aldrin | 14.36 | 254.9 | 219.9 | 20 |
| Allidochlor | 7.73 | 132 | 56.1 | 8 |
| Allidochlor | 7.73 | 132 | 49 | 26 |
| Anthraquinone | 14.38 | 180.1 | 152 | 12 |
| Anthraquinone | 14.38 | 208.1 | 152 | 22 |
| Atrazine | 11.44 | 215.1 | 58.1 | 10 |
| Atrazine | 11.44 | 200.1 | 122 | 8 |
| Azinphos-ethyl | 23.66 | 132 | 77 | 12 |
| Azinphos-ethyl | 23.66 | 132 | 51 | 26 |
| Azinphos-methyl | 22.54 | 132 | 77 | 12 |
| Azinphos-methyl | 22.54 | 160 | 77 | 16 |
| Benfluralin | 10.56 | 292 | 264 | 8 |
| Benfluralin | 10.56 | 292 | 160 | 20 |
| BHC,Alpha | 11.04 | 180.9 | 144.9 | 12 |
| BHC,Alpha | 11.04 | 216.9 | 181 | 8 |
| BHC,Beta | 11.52 | 180.9 | 145 | 14 |
| BHC,Beta | 11.52 | 216.9 | 180.9 | 8 |
| BHC,delta | 12.29 | 180.9 | 144.9 | 14 |
| BHC,delta | 12.29 | 182.9 | 147 | 14 |
| BHC,gamma | 11.71 | 180.9 | 144.9 | 12 |
| BHC,gamma | 11.71 | 216.9 | 180.9 | 8 |
| Bifenthrin | 21.34 | 181 | 165.9 | 10 |
| Bifenthrin | 21.34 | 181 | 179 | 12 |
| Bromfenvinphos | 16.60 | 266.9 | 159 | 14 |
| Bromfenvinphos | 16.60 | 268.9 | 161.1 | 14 |
| Bromfenvinphos -methyl | 15.44 | 294.9 | 109 | 16 |
| Bromfenvinphos -methyl | 15.44 | 294.9 | 79.1 | 30 |

| Compound | RT | Parent Mass | Product Mass | CE |
|------------------------------|-------|-------------|--------------|----|
| Bromfenvinphos -ethyl | 16.00 | 358.8 | 302.8 | 14 |
| Bromfenvinphos -ethyl | 16.00 | 302.8 | 284.8 | 14 |
| Bromophos -metyl (Bromophos) | 14.81 | 330.8 | 315.8 | 14 |
| Bromophos -metyl (Bromophos) | 14.81 | 328.9 | 313.8 | 14 |
| Bromopropylate | 21.36 | 340.8 | 185 | 14 |
| Bromopropylate | 21.36 | 184.9 | 156.9 | 12 |
| Bupirimate | 17.36 | 273.1 | 193.2 | 8 |
| Bupirimate | 17.36 | 273.1 | 108 | 14 |
| Captafol | 20.37 | 183.1 | 79.2 | 8 |
| Captafol | 20.37 | 150.1 | 79 | 6 |
| Captan | 15.64 | 117 | 82 | 30 |
| Captan | 15.64 | 149 | 70 | 20 |
| Carbophenothion | 19.29 | 157 | 45 | 12 |
| Carbophenothion | 19.29 | 342 | 157 | 10 |
| Carfentrazon-ethyl | 19.23 | 340.1 | 312.1 | 10 |
| Carfentrazon-ethyl | 19.23 | 290 | 99.9 | 36 |
| Chlorbenside | 16.04 | 125 | 89 | 16 |
| Chlorbenside | 16.04 | 268 | 125 | 10 |
| Chlordane alpha-cis | 16.49 | 372.8 | 265.9 | 14 |
| Chlordane alpha-cis | 16.49 | 271.8 | 236.8 | 12 |
| Chlordane gamma-trans | 16.1 | 372.8 | 265.9 | 20 |
| Chlordane gamma-trans | 16.1 | 271.9 | 236.9 | 14 |
| Chlorfenapyr | 17.66 | 327.9 | 246.9 | 14 |
| Chlorfenapyr | 17.66 | 248.9 | 137.1 | 18 |
| Chlorfenson | 16.78 | 175 | 111 | 10 |
| Chlorfenson | 16.78 | 111 | 75 | 14 |
| Chlorfenvinphos | 15.40 | 266.9 | 159 | 16 |
| Chlorfenvinphos | 15.40 | 268.9 | 161 | 14 |
| Chlorobenzilate | 18.18 | 139 | 111 | 12 |
| Chlorobenzilate | 18.18 | 251 | 111 | 34 |
| Chloroneb | 9.26 | 190.9 | 113 | 14 |
| Chloroneb | 9.26 | 193 | 53.1 | 32 |
| Cholrothalonil | 12.07 | 263.9 | 132.9 | 40 |
| Cholrothalonil | 12.07 | 265.9 | 170 | 24 |
| Chlopropham | 10.51 | 127 | 65 | 20 |
| Chlopropham | 10.51 | 171 | 127 | 8 |
| Chloropyrifos-ethyl | 14.19 | 313.0 | 257.9 | 12 |
| Chloropyrifos-ethyl | 14.19 | 196.9 | 168.9 | 12 |

ตารางที่ 1 การตั้งชื่อสำหรับวิเคราะห์สารเคมีกำจัดศัตรูพืชชนิดต่างๆ (ต่อ)

| Compound | RT | Parent Mass | Product Mass | CE |
|-----------------------------|-------|-------------|--------------|----|
| Chlorpyrifos-metyl | 12.99 | 285.9 | 92.9 | 20 |
| Chlorpyrifos-metyl | 12.99 | 287.9 | 92.9 | 20 |
| Chlorthal-dimethyl(Dacthal) | 14.35 | 300.9 | 222.9 | 22 |
| Chlorthal-dimethyl(Dacthal) | 14.35 | 300.9 | 272.9 | 12 |
| Chlorthiophos | 18.55 | 324.9 | 268.9 | 12 |
| Chlorthiophos | 18.55 | 268.9 | 205 | 14 |
| Chlozolinate | 15.31 | 186 | 145 | 14 |
| Chlozolinate | 15.31 | 188 | 147 | 14 |
| Clomazone | 11.55 | 125 | 89 | 16 |
| Clomazone | 11.55 | 204 | 107 | 18 |
| Coumaphos | 24.82 | 266 | 163 | 18 |
| Coumaphos | 24.82 | 209.9 | 182 | 10 |
| Cycloate | 10.37 | 154.1 | 83.1 | 8 |
| Cycloate | 10.37 | 154.1 | 55.1 | 18 |
| Cyfluthrin Peak1 | 25.65 | 163 | 127.1 | 6 |
| Cyfluthrin Peak1 | 25.65 | 206 | 151.1 | 18 |
| Cyfluthrin Peak2 | 25.88 | 163 | 127 | 6 |
| Cyfluthrin Peak2 | 25.88 | 206 | 151.1 | 18 |
| Cyfluthrin Peak3 | 25.95 | 163 | 127 | 6 |
| Cyfluthrin Peak3 | 25.95 | 226 | 206.1 | 18 |
| Cyfluthrin Peak4 | 26.04 | 163 | 127 | 6 |
| Cyfluthrin Peak4 | 26.04 | 226 | 206.1 | 10 |
| Cyhalothrin (lamboda) | 23.18 | 180.9 | 152 | 22 |
| Cyhalothrin (lamboda) | 23.18 | 197.1 | 141.1 | 10 |
| Cypermethrin Peak1 | 26.29 | 163 | 127.1 | 6 |
| Cypermethrin Peak1 | 26.29 | 180.9 | 151.9 | 18 |
| Cypermethrin Peak2 | 26.49 | 163 | 127 | 6 |
| Cypermethrin Peak2 | 26.49 | 180.9 | 151.9 | 18 |
| Cypermethrin Peak3 | 26.56 | 163 | 127 | 6 |
| Cypermethrin Peak3 | 26.56 | 163 | 91 | 12 |
| Cypermethrin Peak4 | 26.63 | 163 | 127.1 | 6 |
| Cypermethrin Peak4 | 26.63 | 180.9 | 152.2 | 20 |
| Cyprodinil | 15.15 | 224.1 | 208.1 | 18 |
| Cyprodinil | 15.15 | 224.1 | 197.1 | 20 |
| DDD p,p | 18.43 | 235 | 165 | 20 |
| DDD p,p | 18.43 | 235 | 299 | 14 |
| DDD o,p | 17.35 | 235 | 165 | 20 |
| DDD o,p | 17.35 | 235 | 199 | 14 |
| DDE o,p | 16.14 | 246 | 176.1 | 28 |
| DDE o,p | 16.14 | 248 | 176.1 | 30 |

| Compound | RT | Parent Mass | Product Mass | CE |
|-------------------------------|-------|-------------|--------------|----|
| DDE p,p | 17.14 | 246 | 176.1 | 28 |
| DDE p,p | 17.14 | 317.9 | 248 | 18 |
| DDT o,p | 18.54 | 235 | 165.1 | 22 |
| DDT o,p | 18.54 | 235 | 199.1 | 10 |
| DDT p,p | 19.68 | 235 | 165.1 | 22 |
| DDT p,p | 19.68 | 236.8 | 165 | 22 |
| Deltamethrin | 29.27 | 252.8 | 92.9 | 16 |
| Deltamethrin | 29.27 | 252.8 | 172 | 8 |
| Diallate-cis | 11.06 | 234.1 | 150 | 18 |
| Diallate-cis | 11.06 | 235.8 | 152 | 18 |
| Diallate-trans | 10.88 | 234.1 | 150 | 18 |
| Diallate-trans | 10.88 | 235.8 | 152 | 18 |
| Diazinon | 11.82 | 137.1 | 84.1 | 12 |
| Diazinon | 11.82 | 137.1 | 54.1 | 20 |
| Dichlobenil | 8.14 | 170.9 | 99.9 | 24 |
| Dichlobenil | 8.14 | 170.9 | 136 | 12 |
| Dichlofluanid | 13.97 | 224 | 123 | 10 |
| Dichlofluanid | 13.97 | 226 | 123 | 10 |
| Dichlorobenzophe- none,4,4 | 14.61 | 139 | 111 | 12 |
| Dichlorobenzophe- none,4,4 | 14.61 | 139 | 74.9 | 26 |
| Dicloran(Bortran) | 11.30 | 206 | 176 | 10 |
| Dicloran(Bortran) | 11.30 | 160 | 124.1 | 8 |
| Dieldrin | 17.32 | 276.9 | 240.8 | 6 |
| Dieldrin | 17.32 | 262.9 | 190.9 | 30 |
| Dimehachlor | 12.85 | 197.1 | 148 | 10 |
| Dimehachlor | 12.85 | 134 | 77 | 24 |
| Diphenamid | 14.81 | 167.1 | 165.1 | 20 |
| Diphenamid | 14.81 | 167.1 | 152.1 | 16 |
| Diphenylamine | 10.3 | 168.1 | 167.1 | 14 |
| Diphenylamine | 10.3 | 169.1 | 167.1 | 24 |
| Disulfoton | 12.11 | 88 | 59.8 | 6 |
| Disulfoton | 12.11 | 142 | 81 | 10 |
| Edifenphos | 19.39 | 172.9 | 109 | 8 |
| Edifenphos | 19.39 | 310 | 109 | 26 |
| Endosulfan ether | 12.76 | 238.9 | 204 | 12 |
| Endosulfan ether | 12.76 | 240.9 | 206 | 14 |
| Endosulfan peak 1 | 16.49 | 194.9 | 160 | 8 |
| Endosulfan peak 1 | 16.49 | 240.8 | 205.8 | 14 |

ตารางที่ 1 การตั้งค่างานสำหรับวิเคราะห์สารเคมีกำจัดศัตรูพืชชนิดต่างๆ (ต่อ)

| Compound | RT | Parent Mass | Product Mass | CE |
|-------------------------|-------|-------------|--------------|----|
| Endosulfan Peak 2 | 18.29 | 194.9 | 159 | 8 |
| Endosulfan Peak 2 | 18.29 | 158.9 | 123 | 12 |
| Endosulfan sulfate | 19.53 | 271.7 | 236.8 | 12 |
| Endosulfan sulfate | 19.53 | 238.7 | 203.9 | 12 |
| Endrin | 17.96 | 280.8 | 244.9 | 8 |
| Endrin | 17.96 | 244.9 | 173 | 22 |
| Endrin Aldehyde | 18.75 | 214.9 | 214.9 | 24 |
| Endrin Aldehyde | 18.75 | 173 | 138.1 | 16 |
| Endrin-Ketone | 21.06 | 316.8 | 281 | 10 |
| Endrin-Ketone | 21.06 | 316.8 | 208.9 | 28 |
| EPN | 21.31 | 169 | 77 | 22 |
| EPN | 21.31 | 169 | 141 | 8 |
| Esfenvalerate | 28.35 | 167 | 125 | 10 |
| Esfenvalerate | 28.35 | 125 | 89 | 18 |
| Ethafluralin | 10.38 | 276 | 202 | 14 |
| Ethafluralin | 10.38 | 315.9 | 276.1 | 8 |
| Ethion | 18.44 | 230.9 | 128.9 | 22 |
| Ethion | 18.44 | 230.9 | 174.9 | 12 |
| Etofenprox | 26.88 | 163.1 | 107.1 | 16 |
| Etofenprox | 26.88 | 163.1 | 135.1 | 10 |
| Etridiazole (Terrazole) | 8.88 | 182.8 | 139.9 | 14 |
| Etridiazole (Terrazole) | 8.88 | 211 | 139.9 | 18 |
| Fenamiphos | 16.66 | 154 | 139 | 10 |
| Fenamiphos | 16.66 | 303.1 | 195 | 8 |
| Fenarimol | 23.44 | 139 | 74.9 | 26 |
| Fenarimol | 23.44 | 139 | 111 | 14 |
| Fenchlorfos | 13.42 | 227 | 260 | 6 |
| Fenchlorfos | 13.42 | 227 | 109 | 16 |
| Fenitrothion | 13.76 | 277 | 260 | 6 |
| Fenitrothion | 13.76 | 277 | 109 | 16 |
| Fenpropathrin | 21.64 | 181 | 151.9 | 22 |
| Fenpropathrin | 21.64 | 181 | 126.8 | 28 |
| Fenson | 14.77 | 141 | 77 | 8 |
| Fenson | 14.77 | 278 | 125 | 14 |
| Fenthion | 14.29 | 278 | 109 | 18 |
| Fenthion | 14.29 | 278 | 125 | 14 |
| Fenvalerate | 27.96 | 167 | 125 | 10 |
| Fenvalerate | 27.96 | 167 | 125 | 10 |
| Fipronil | 15.25 | 366.9 | 212.9 | 28 |
| Fipronil | 15.25 | 368.9 | 214.9 | 30 |
| Fluazifop-P-butyl | 17.91 | 282.1 | 91.1 | 18 |
| Fluazifop-P-butyl | 17.91 | 282.1 | 238.1 | 16 |

| Compound | RT | Parent Mass | Product Mass | CE |
|---------------------|--------|-------------|--------------|----|
| Fluchloralin | 11.865 | 306 | 264 | 8 |
| Fluchloralin | 11.865 | 326 | 63 | 12 |
| Flucythrinate Peak1 | 26.58 | 157 | 107.1 | 12 |
| Flucythrinate Peak1 | 26.58 | 199.1 | 107.1 | 22 |
| Flucythrinate Peak2 | 26.99 | 157 | 107 | 12 |
| Flucythrinate Peak2 | 26.99 | 199 | 107 | 22 |
| Flodioxonil | 16.92 | 248 | 127 | 26 |
| Flodioxonil | 16.92 | 248 | 182 | 10 |
| Fluquinconazole | 24.86 | 340 | 298 | 16 |
| Fluquinconazole | 24.86 | 340 | 108.1 | 36 |
| Fluridone | 27.29 | 328.1 | 189.1 | 38 |
| Fluridone | 27.29 | 328.1 | 258.8 | 24 |
| Flusilazole | 17.33 | 233.1 | 164.9 | 16 |
| Flusilazole | 17.33 | 233.1 | 151.9 | 14 |
| Flutolanil | 16.74 | 173 | 145 | 14 |
| Flutolanil | 16.74 | 173 | 95 | 28 |
| Flutriafol | 16.59 | 123 | 75 | 24 |
| Flutriafol | 16.59 | 219.1 | 123 | 12 |
| Fluvalinate Peak1 | 28.19 | 250 | 55.1 | 16 |
| Fluvalinate Peak1 | 28.19 | 250 | 199.9 | 18 |
| Fluvalinate Peak2 | 28.34 | 250 | 55.1 | 16 |
| Fluvalinate Peak2 | 28.34 | 250 | 200 | 16 |
| Folpet | 15.82 | 259.9 | 130 | 14 |
| Folpet | 15.82 | 261.9 | 130 | 14 |
| Fonofos | 11.86 | 109 | 62.9 | 10 |
| Fonofos | 11.86 | 264 | 109 | 14 |
| Heptachlor | 13.42 | 271.8 | 236.8 | 12 |
| Heptachlor | 13.42 | 273.8 | 238.8 | 14 |
| Heptachlor epoxide | 15.41 | 352.8 | 262.9 | 16 |
| Heptachlor epoxide | 15.41 | 354.7 | 264.9 | 12 |
| Hexachlorobenzene | 11.15 | 281.8 | 211.8 | 28 |
| Hexachlorobenzene | 11.15 | 283.8 | 213.8 | 30 |
| Hexazinone | 19.85 | 171.1 | 71.1 | 14 |
| Hexazinone | 19.85 | 171.1 | 85.1 | 12 |
| Iodofenfos | 16.78 | 376.8 | 361.8 | 16 |
| Iodofenfos | 16.78 | 378.8 | 363.8 | 14 |
| Iprodione | 21.02 | 314 | 245 | 10 |
| Iprodione | 21.02 | 315.7 | 247 | 10 |
| Isazophos | 12.11 | 256.9 | 161.9 | 4 |
| Isazophos | 12.11 | 118.9 | 76 | 18 |

ตารางที่ 1 การตั้งค่าสำหรับวิเคราะห์สารเคมีกำจัดศัตรูพืชชนิดต่างๆ (ต่อ)

| Compound | RT | Parent Mass | Product Mass | CE |
|----------------------------------|-------|-------------|--------------|----|
| Isodrin | 15.15 | 192.9 | 123 | 28 |
| Isodrin | 15.15 | 192.9 | 157 | 20 |
| Isopropalin | 14.91 | 280.1 | 238.2 | 8 |
| Isopropalin | 14.91 | 280.1 | 180.2 | 10 |
| Lenacil | 19.56 | 153 | 82.1 | 16 |
| Lenacil | 19.56 | 153 | 110 | 14 |
| Leptophos | 22.48 | 171 | 124.3 | 10 |
| Leptophos | 22.48 | 171 | 51 | 38 |
| Linuron | 13.95 | 187 | 124 | 20 |
| Linuron | 13.95 | 248 | 61.1 | 8 |
| Malathion | 13.97 | 158 | 125 | 6 |
| Malathion | 13.97 | 173.1 | 99 | 12 |
| Metalaxyl | 13.34 | 234.1 | 146.1 | 20 |
| Metalaxyl | 13.34 | 249.2 | 190.1 | 6 |
| Metazachlor | 15.17 | 209 | 132.1 | 16 |
| Metazachlor | 15.17 | 133.1 | 132.1 | 12 |
| Methacrifos | 9.16 | 124.9 | 47.1 | 12 |
| Methacrifos | 9.16 | 207.9 | 180.1 | 6 |
| Methoxychlor | 21.52 | 227.1 | 141.1 | 32 |
| Methoxychlor | 21.52 | 227.1 | 169.1 | 22 |
| Metolachlor | 14.15 | 238.1 | 162.1 | 10 |
| Metolachlor | 14.15 | 162.1 | 133.1 | 14 |
| Mevinphos | 8.66 | 192 | 127 | 10 |
| Mevinphos | 8.66 | 127 | 95 | 14 |
| MEK-264 A | 14.84 | 164.1 | 98.1 | 10 |
| MEK-264 A | 14.84 | 164.1 | 80.1 | 24 |
| MEK-264 B | 15.19 | 164.1 | 98.1 | 12 |
| MEK-264 B | 15.19 | 164.1 | 67.1 | 6 |
| Mirex | 23.16 | 272 | 236.8 | 14 |
| Mirex | 23.16 | 273.8 | 238.8 | 14 |
| Myclobutanil | 17.25 | 179 | 125 | 14 |
| Myclobutanil | 17.25 | 150 | 123 | 14 |
| N-(2,4-Dimethylphenyl) formamide | 9.11 | 149.1 | 120.1 | 14 |
| N-(2,4-Dimethylphenyl) formamide | 9.11 | 149.1 | 106.1 | 16 |
| Nitralin | 20.45 | 316.2 | 274 | 8 |
| Nitralin | 20.45 | 274 | 169 | 20 |
| Nitrofen | 17.89 | 202 | 139 | 24 |
| Nitrofen | 17.89 | 283 | 162 | 20 |
| Nonachlor-cis | 18.47 | 408.8 | 299.9 | 18 |
| Nonachlor-cis | 18.47 | 406.8 | 299.9 | 14 |

| Compound | RT | Parent Mass | Product Mass | CE |
|-------------------------|-------|-------------|--------------|----|
| Nonachlor-trans | 16.59 | 406.8 | 299.8 | 14 |
| Nonachlor-trans | 16.59 | 408.8 | 299.8 | 18 |
| Norflurazon | 19.39 | 303 | 145 | 20 |
| Norflurazon | 19.39 | 145 | 95 | 16 |
| Ortho-phenylphenol | 9.43 | 170.1 | 112 | 12 |
| Ortho-phenylphenol | 9.43 | 258 | 175 | 6 |
| Oxadiazon | 17.14 | 175 | 115 | 34 |
| Oxadiazon | 17.14 | 258 | 175 | 6 |
| Oxyfluorfen | 17.32 | 252 | 146 | 30 |
| Oxyfluorfen | 17.32 | 300 | 223 | 14 |
| Paclobutrazol | 16.24 | 236 | 146 | 30 |
| Paclobutrazol | 16.24 | 300 | 223 | 14 |
| Parathion(ethyl) | 14.39 | 138.9 | 109 | 6 |
| Parathion(ethyl) | 14.39 | 291 | 109 | 12 |
| Parathion-methyl | 13.1 | 263 | 109 | 12 |
| Parathion-methyl | 13.1 | 263 | 79 | 30 |
| Pebulate | 8.91 | 128.1 | 57.1 | 8 |
| Pebulate | 8.91 | 128 | 72 | 6 |
| Penconazole | 15.29 | 248.1 | 157 | 22 |
| Penconazole | 15.29 | 159 | 123 | 20 |
| Pendimethalin | 15.11 | 252.1 | 162.1 | 8 |
| Pendimethalin | 15.11 | 252.1 | 161.1 | 14 |
| Pentachloroanline | 12.74 | 262.9 | 191.9 | 20 |
| Pentachloroanline | 12.74 | 264.9 | 193.6 | 18 |
| Pentachloroanisole | 11.24 | 264.8 | 236.9 | 10 |
| Pentachloroanisole | 11.24 | 279.9 | 236.8 | 22 |
| Pentachlorobenzene | 9.46 | 247.9 | 212.9 | 18 |
| Pentachlorobenzene | 9.46 | 248 | 142 | 42 |
| Pentachlorobenzonitrile | 11.71 | 272.9 | 237.9 | 16 |
| Pentachlorobenzonitrile | 11.71 | 274.8 | 204.9 | 28 |
| Pentachlorothioanisole | 13.95 | 295.7 | 262.9 | 12 |
| Pentachlorothioanisole | 13.95 | 295.7 | 245.9 | 30 |
| Cis-permethrin | 24.6 | 183.1 | 153 | 12 |
| Cis-permethrin | 24.6 | 183.1 | 168 | 12 |
| Trans-permethrin | 24.88 | 183 | 168.1 | 10 |
| Trans-permethrin | 24.88 | 183 | 165.1 | 10 |
| Perthane (Ethylan) | 17.92 | 223.1 | 167 | 12 |
| Perthane (Ethylan) | 17.92 | 223.1 | 193 | 28 |

ตารางที่ 1 การตั้งค่าสำหรับวิเคราะห์สารเคมีกำจัดศัตรูพืชชนิดต่างๆ (ต่อ)

| Compound | RT | Parent Mass | Product Mass | CE |
|--------------------|-------|-------------|--------------|----|
| Phenothrin | 22.33 | 123.1 | 41.1 | 24 |
| Phenothrin | 22.33 | 123.1 | 81.1 | 8 |
| Phorate | 10.88 | 260 | 75 | 8 |
| Phorate | 10.88 | 121 | 65 | 10 |
| Phosalone | 22.43 | 182 | 111 | 14 |
| Phosalone | 22.43 | 182 | 74.8 | 30 |
| Phosmet | 21.18 | 160 | 133 | 10 |
| Phosmet | 21.18 | 160 | 50.9 | 38 |
| Phthalimide | 9.04 | 147 | 76 | 25 |
| Phthalimide | 9.04 | 103.7 | 76 | 10 |
| Piperonyl butoxide | 20.43 | 176.1 | 103.1 | 22 |
| Piperonyl butoxide | 20.43 | 176.1 | 131.1 | 12 |
| Pirimiphos-ethyl | 14.76 | 304.1 | 168.1 | 12 |
| Pirimiphos-ethyl | 14.76 | 318.1 | 166.1 | 12 |
| Pirimiphos-methyl | 13.67 | 290.1 | 125 | 20 |
| Pirimiphos-methyl | 13.67 | 290.1 | 233 | 8 |
| Pretilachlor | 16.93 | 162 | 132.1 | 20 |
| Pretilachlor | 16.93 | 262.1 | 202.1 | 6 |
| Prochloraz | 24.98 | 180 | 69 | 14 |
| Prochloraz | 24.98 | 180.1 | 138.1 | 12 |
| procymidone | 15.69 | 283 | 96.1 | 8 |
| procymidone | 15.69 | 285 | 96.1 | 10 |
| Prodiamine | 13.72 | 321.1 | 279.1 | 6 |
| Prodiamine | 13.72 | 275.1 | 255.1 | 8 |
| Profenofos | 17.0 | 336.9 | 266.9 | 12 |
| Profenofos | 17.0 | 338.9 | 268.9 | 14 |
| Profluralin | 11.59 | 318.1 | 199.1 | 12 |
| Profluralin | 11.59 | 347.1 | 330.1 | 6 |
| Propachlor | 10.11 | 176.1 | 57.1 | 8 |
| Propachlor | 10.11 | 120 | 77 | 16 |
| Propanil | 12.90 | 161 | 90 | 24 |
| Propanil | 12.90 | 161 | 99 | 24 |
| Propargite | 20.25 | 135.1 | 107.1 | 12 |
| Propargite | 20.25 | 135.1 | 77.1 | 26 |
| Propisochlor | 13.25 | 162.1 | 120.1 | 12 |
| Propisochlor | 13.25 | 162.1 | 144.1 | 8 |
| Prothiofos | 16.87 | 309 | 238.9 | 14 |
| Prothiofos | 16.87 | 266.9 | 220.9 | 18 |
| Propyzamide | 11.82 | 172.9 | 109 | 24 |
| Propyzamide | 11.82 | 172.9 | 145 | 14 |

| Compound | RT | Parent Mass | Product Mass | CE |
|-------------------|-------|-------------|--------------|----|
| Pyraclofos | 23.98 | 194 | 138 | 18 |
| Pyraclofos | 23.98 | 360 | 194.1 | 12 |
| Pyrazophos | 23.48 | 221 | 148.7 | 14 |
| Pyrazophos | 23.48 | 231.9 | 204.1 | 10 |
| Pyridaben | 24.87 | 147.1 | 117.1 | 20 |
| Pyridaben | 24.87 | 147.1 | 132.1 | 12 |
| Pyridaphenthion | 20.98 | 340 | 199.1 | 8 |
| Pyridaphenthion | 20.98 | 199 | 92.1 | 14 |
| Pyrimethanil | 12.00 | 198.1 | 118 | 32 |
| Pyrimethanil | 12.00 | 198.1 | 158.1 | 18 |
| Pyriproxyfen | 22.79 | 136.1 | 96 | 10 |
| Pyriproxyfen | 22.79 | 136.1 | 78 | 20 |
| Quinalphos | 15.58 | 146 | 118.1 | 10 |
| Quinalphos | 15.58 | 157.1 | 102 | 22 |
| Quintozene | 11.63 | 294.8 | 236.9 | 14 |
| Quintozene | 11.63 | 213.8 | 178.9 | 14 |
| Resmethrin Peak1 | 20.30 | 123.1 | 81.1 | 8 |
| Resmethrin Peak1 | 20.30 | 142 | 128.1 | 10 |
| Resmethrin Peak2 | 20.52 | 171 | 127.9 | 14 |
| Resmethrin Peak2 | 20.52 | 143 | 128 | 10 |
| Sulfotep | 10.63 | 322 | 145.9 | 22 |
| Sulfotep | 10.63 | 237.9 | 145.9 | 12 |
| Sulprofos | 18.96 | 156 | 108 | 30 |
| Sulprofos | 18.96 | 322 | 156.1 | 10 |
| Tebuconazole | 20.13 | 250 | 125 | 20 |
| Tebuconazole | 20.13 | 125 | 89 | 16 |
| Tebufenpyrad | 21.80 | 276.1 | 171 | 10 |
| Tebufenpyrad | 21.80 | 318.1 | 131.1 | 14 |
| Tecnazene | 10.02 | 258.9 | 201 | 12 |
| Tecnazene | 10.02 | 214.8 | 178.9 | 8 |
| Tefluthrin | 12.10 | 177 | 127 | 14 |
| Tefluthrin | 12.10 | 177 | 137 | 16 |
| Terbacil | 12.15 | 161 | 144 | 12 |
| Terbacil | 12.15 | 160 | 76 | 12 |
| Terbufos | 11.73 | 231 | 128.9 | 20 |
| Terbufos | 11.73 | 231 | 175 | 10 |
| Terbutylazine | 11.73 | 214.1 | 104.1 | 16 |
| Terbutylazine | 11.73 | 214.1 | 132.1 | 10 |
| Tetrachlorvinphos | 16.20 | 328.9 | 109 | 18 |
| Tetrachlorvinphos | 16.20 | 330.9 | 109 | 18 |

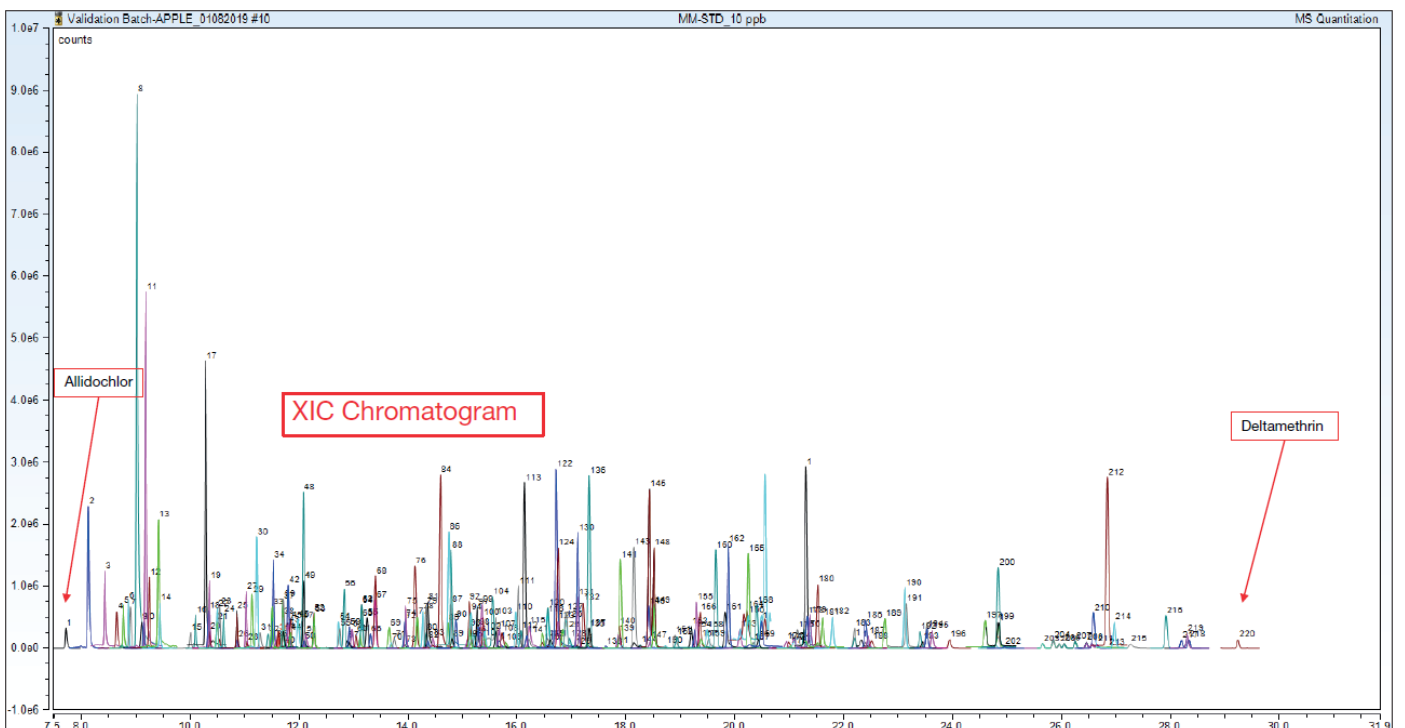
ตารางที่ 1 การตั้งค่าสำหรับวิเคราะห์สารเคมีกำจัดศัตรูพืชชนิดต่างๆ (ต่อ)

| Compound | RT | Parent Mass | Product Mass | CE |
|------------------------------|-------|-------------|--------------|----|
| Tetradifon | 22.23 | 159 | 111 | 20 |
| Tetradifon | 22.23 | 159 | 74.8 | 32 |
| Tetrahydrophthalimide (THPI) | 9.2 | 151 | 77.1 | 32 |
| Tetrahydrophthalimide (THPI) | 9.2 | 151 | 79.9 | 6 |
| Tetramethrin Peak1 | 21.12 | 164 | 107.1 | 12 |
| Tetramethrin Peak1 | 21.12 | 164 | 77.1 | 24 |
| Tetramethrin Peak2 | 21.41 | 164 | 77.1 | 22 |
| Tetramethrin Peak2 | 21.41 | 164 | 107.1 | 12 |
| Tolclofos-methyl | 13.17 | 265 | 219.9 | 20 |
| Tolclofos-methyl | 13.17 | 265 | 250 | 12 |
| Tolyfluamid | 15.36 | 238 | 137 | 10 |
| Tolyfluamid | 15.36 | 240 | 137 | 14 |
| Transfluthrin | 13.17 | 163 | 143 | 14 |
| Transfluthrin | 13.17 | 163 | 91.1 | 12 |

| Compound | RT | Parent Mass | Product Mass | CE |
|--------------------|-------|-------------|--------------|----|
| Triadimefos | 14.48 | 208 | 126.7 | 12 |
| Triadimefos | 14.48 | 208 | 111 | 20 |
| Triadimenol | 15.69 | 128 | 65 | 18 |
| Triadimenol | 15.69 | 168.1 | 70 | 10 |
| Triallate | 12.29 | 268 | 183.9 | 18 |
| Triallate | 12.29 | 268 | 226 | 12 |
| Triazophos | 18.93 | 161.1 | 134.1 | 8 |
| Triazophos | 18.93 | 257 | 162.1 | 6 |
| Triflumizole | 15.75 | 206 | 179 | 14 |
| Triflumizole | 15.75 | 179 | 144 | 14 |
| Trifluralin | 10.51 | 306.1 | 264.1 | 8 |
| Trifluralin | 10.51 | 264 | 160 | 14 |
| Triphenylphosphate | 20.28 | 215 | 168.1 | 16 |
| Triphenylphosphate | 20.28 | 326.1 | 169.1 | 28 |
| Vinclozolin | 13.06 | 197.9 | 145 | 14 |
| Vinclozolin | 13.06 | 212 | 172 | 14 |

ผลการวิเคราะห์

ในการวิเคราะห์สารกำจัดศัตรูพืชตกค้างในแอปเปิลจำนวน 212 ชนิด โดยใช้ GC-(AEI)-MS/MS มีการใช้วิธีการสกัดแบบ QuEChERS ร่วมด้วยสามารถวิเคราะห์หาปริมาณสารกำจัดศัตรูพืชตกค้างได้ จะเห็นได้ว่าการใช้เทคนิค GC-(AEI)-MS/MS เป็นวิธีที่จำเพาะเจาะจงต่อสารที่ต้องการวิเคราะห์สูง ดังผลการวิเคราะห์ที่แสดงในรูปที่ 2



รูปที่ 2 โครมาโทแกรมของสารเคมีปราบศัตรูพืช 212 ชนิดที่วิเคราะห์ด้วย GC-MS/MS

ตารางที่ 2 ขีดความสามารถในการตรวจวัดสารกำจัดศัตรูพืชตกค้างในแอปเปิล

| Compound | R ² | Range | LOQ | Compound | R ² | Range | LOQ |
|------------------------------|----------------|--------------|-------|------------------------------|----------------|--------------|-------|
| 2,3,5,6-Tetrachloroanline | 0.990 | 0.0001-0.05 | 0.001 | Chlorpyrifos-ethyl | 0.9991 | 0.0001-0.05 | 0.001 |
| 4,4'-Methoxychlor olefin | 0.9993 | 0.0001-0.05 | 0.001 | Chlorpyrifos-metyl | 0.9984 | 0.00025-0.05 | 0.001 |
| Acetochlor | 0.9993 | 0.0001-0.05 | 0.001 | Chlorthal-dimethyl (Dacthal) | 0.9986 | 0.0001-0.05 | 0.001 |
| Acrinathrin | 0.995 | 0.00025-0.05 | 0.001 | Chlorthiophos | 0.9982 | 0.0001-0.05 | 0.001 |
| Alachlor | 0.9979 | 0.00025-0.05 | 0.001 | Chlozolate | 0.9981 | 0.00025-0.05 | 0.001 |
| Aldrin | 0.9995 | 0.00025-0.05 | 0.001 | Clomazone | 0.9989 | 0.0001-0.05 | 0.001 |
| Allidochlor | 0.9992 | 0.00025-0.05 | 0.001 | Coumaphos | 0.9996 | 0.00025-0.05 | 0.001 |
| Anthraquinone | 0.9956 | 0.00025-0.05 | 0.001 | Cycloate | 0.9984 | 0.00025-0.05 | 0.001 |
| Atrazine | 0.9995 | 0.00025-0.05 | 0.001 | Cyfluthrin Peak1 | 0.9999 | 0.0005-0.05 | 0.001 |
| Azinphos-ethyl | 0.9995 | 0.0005-0.05 | 0.001 | Cyfluthrin Peak2 | 0.999 | 0.00025-0.05 | 0.001 |
| Azinphos-methyl | 0.9993 | 0.0005-0.05 | 0.001 | Cyfluthrin Peak3 | 0.9999 | 0.00025-0.05 | 0.001 |
| Benfluralin | 0.9973 | 0.00025-0.05 | 0.001 | Cyfluthrin Peak4 | 0.9999 | 0.00025-0.05 | 0.001 |
| BHC,Alpha | 0.9987 | 0.0001-0.05 | 0.001 | Cyhalothrin (lamboda) | 0.9996 | 0.0001-0.05 | 0.001 |
| BHC,Beta | 0.9991 | 0.0001-0.05 | 0.001 | Cypermethrin Peak1 | 0.9998 | 0.0005-0.05 | 0.001 |
| BHC,delta | 0.9985 | 0.0001-0.05 | 0.001 | Cypermethrin Peak2 | 0.9997 | 0.0005-0.05 | 0.001 |
| BHC,gamma | 0.9988 | 0.0001-0.05 | 0.001 | Cypermethrin Peak3 | 0.9999 | 0.001-0.05 | 0.005 |
| Bifenthrin | 0.9993 | 0.0025-0.05 | 0.001 | Cypermethrin Peak4 | 0.9994 | 0.001-0.05 | 0.005 |
| Bromfenvinphos | 0.9991 | 0.0001-0.05 | 0.001 | Cyprodinil | 0.9989 | 0.00025-0.05 | 0.001 |
| Bromfenvinphos -methyl | 0.9960 | 0.0005-0.05 | 0.001 | DDD p,p | 0.992 | 0.0001-0.05 | 0.001 |
| Bromfenvinphos -ethyl | 0.9993 | 0.0001-0.05 | 0.001 | DDD o,p | 0.9993 | 0.0001-0.05 | 0.001 |
| Bromophos -metyl (Bromophos) | 0.9993 | 0.0001-0.05 | 0.001 | DDE o,p | 0.9995 | 0.001-0.05 | 0.001 |
| Bromopropylate | 0.9995 | 0.0001-0.05 | 0.001 | DDE p,p | 0.9994 | 0.0001-0.05 | 0.001 |
| Bupirimate | 0.9978 | 0.00025-0.05 | 0.001 | DDT o,p | 0.9981 | 0.0001-0.05 | 0.001 |
| Captafol | 0.9931 | 0.005-0.500 | 0.010 | DDT p,p | 0.9993 | 0.0001-0.05 | 0.001 |
| Captan | 0.9883 | 0.0025-0.500 | 0.010 | Deltamethrin | 0.9999 | 0.00025-0.05 | 0.001 |
| Carbophenothion | 0.9978 | 0.00025-0.05 | 0.001 | Diallate-cis | 0.9982 | 0.00025-0.05 | 0.001 |
| Carfentrazon-ethyl | 0.9998 | 0.00025-0.05 | 0.001 | Diallate-trans | 0.9985 | 0.0001-0.05 | 0.001 |
| Chlorbenside | 0.9985 | 0.0001-0.05 | 0.001 | Diazinon | 0.9975 | 0.00025-0.05 | 0.001 |
| Chlordane alpha-cis | 0.9992 | 0.000-0.05 | 0.001 | Dichlobenil | 0.9990 | 0.0001-0.05 | 0.001 |
| Chlordane gamma-trans | 0.9986 | 0.00025-0.05 | 0.001 | Dichlofluanid | 0.9987 | 0.0001-0.05 | 0.001 |
| Chlorfenapyr | 0.9994 | 0.0005-0.05 | 0.002 | Dichlorobenzophe- none,4,4 | 0.9978 | 0.0001-0.05 | 0.001 |
| Chlorfenson | 0.9971 | 0.00025-0.05 | 0.001 | Dicloran (Bortran) | 0.9987 | 0.00025-0.05 | 0.001 |
| Chlorfenvinphos | 0.9976 | 0.00025-0.05 | 0.001 | Dieldrin | 0.9989 | 0.0005-0.05 | 0.001 |
| Chlorobenzilate | 0.9994 | 0.0001-0.05 | 0.001 | Dimehachlor | 0.9989 | 0.0005-0.05 | 0.001 |
| Chloroneb | 0.9988 | 0.00025-0.05 | 0.001 | Diphenamid | 0.9967 | 0.00025-0.05 | 0.001 |
| Cholrothalonil | 0.9985 | 0.00025-0.05 | 0.001 | Diphenylamine | 0.9978 | 0.0001-0.05 | 0.001 |
| Chlopropham | 0.9985 | 0.00025-0.05 | 0.001 | Disulfoton | 0.9981 | 0.0005-0.05 | 0.001 |
| | | | | Edifenphos | 0.9988 | 0.00025-0.05 | 0.001 |
| | | | | Endosulfan ether | 0.9992 | 0.0001-0.05 | 0.001 |

* LOQ in ppm (mg/kg) unit

ตารางที่ 2 ขีดความสามารถในการตรวจวัดสารกำจัดศัตรูพืชตกค้างในแอปเปิล (ต่อ)

| Compound | R ² | Range | LOQ | Compound | R ² | Range | LOQ |
|-------------------------|----------------|--------------|-------|----------------------------------|----------------|--------------|-------|
| Endosulfan Peak 1 | 0.9991 | 0.00025-0.05 | 0.001 | Iprodione | 0.9999 | 0.0005-0.05 | 0.001 |
| Endosulfan Peak 2 | 0.9993 | 0.0005-0.05 | 0.001 | Isazophos | 0.9991 | 0.0005-0.05 | 0.001 |
| Endosulfan sulfate | 0.9995 | 0.00025-0.05 | 0.001 | Isodrin | 0.9986 | 0.00025-0.05 | 0.001 |
| Endrin | 0.9995 | 0.00025-0.05 | 0.001 | Isopropalin | 0.9961 | 0.0005-0.05 | 0.001 |
| Endrin Aldehyde | 0.9972 | 0.00025-0.05 | 0.001 | Lenacil | 0.9990 | 0.0005-0.05 | 0.001 |
| Endrin-Ketone | 0.9989 | 0.0005-0.05 | 0.001 | Leptophos | 0.9987 | 0.0001-0.05 | 0.001 |
| EPN | 0.9991 | 0.0005-0.05 | 0.001 | Linuron | 0.9958 | 0.001-0.05 | 0.005 |
| Esfenvalerate | 0.9998 | 0.0005-0.05 | 0.001 | Malathion | 0.9981 | 0.0001-0.05 | 0.001 |
| Ethafluralin | 0.9977 | 0.0005-0.05 | 0.001 | Metalaxyl | 0.9986 | 0.00025-0.05 | 0.001 |
| Ethion | 0.9986 | 0.0001-0.05 | 0.001 | Metazachlor | 0.9974 | 0.0025-0.05 | 0.001 |
| Etofenprox | 0.9999 | 0.0001-0.05 | 0.001 | Methacrifos | 0.9983 | 0.00025-0.05 | 0.001 |
| Etridiazole (Terrazole) | 0.9990 | 0.0001-0.05 | 0.001 | Methoxychlor | 0.9989 | 0.0001-0.05 | 0.001 |
| FEnamiphos | 0.9992 | 0.0005-0.05 | 0.001 | Metolachlor | 0.9993 | 0.0001-0.05 | 0.001 |
| Fenarimol | 0.9994 | 0.0001-0.05 | 0.001 | Mevinphos | 0.9987 | 0.0001-0.05 | 0.001 |
| Fenchlorfos | 0.9989 | 0.0005-0.05 | 0.001 | MEK-264 A | 0.9973 | 0.00025-0.05 | 0.001 |
| Fenitrothion | 0.9968 | 0.0005-0.05 | 0.001 | MEK-264 B | 0.9946 | 0.0001-0.05 | 0.001 |
| Fenpropathrin | 0.9989 | 0.0005-0.05 | 0.001 | Mirex | 0.9992 | 0.0001-0.05 | 0.001 |
| Fenson | 0.9990 | 0.0025-0.05 | 0.001 | Myclobutanil | 0.9986 | 0.00025-0.05 | 0.001 |
| Fenthion | 0.9990 | 0.0001-0.05 | 0.001 | N-(2,4-Dimethylphenyl) formamide | 0.9958 | 0.0005-0.05 | 0.001 |
| Fenvalerate | 0.9998 | 0.0001-0.05 | 0.001 | Nitralin | 0.9955 | 0.0005-0.05 | 0.001 |
| Fipronil | 0.9973 | 0.0005-0.05 | 0.001 | Nitrofen | 0.9990 | 0.00025-0.05 | 0.001 |
| Fluazifop-P-butyl | 0.9980 | 0.0001-0.05 | 0.001 | Nonachlor-cis | 0.9986 | 0.00025-0.05 | 0.001 |
| Fluchloralin | 0.9967 | 0.00025-0.05 | 0.001 | Nonachlor-trans | 0.9994 | 0.0001-0.05 | 0.001 |
| Flucythrinate peak1 | 0.9998 | 0.00025-0.05 | 0.001 | Norflurazon | 0.9980 | 0.00025-0.05 | 0.001 |
| Flucythrinate peak2 | 0.9998 | 0.0001-0.05 | 0.001 | Ortho-phenylphenol | 0.9982 | 0.00025-0.05 | 0.001 |
| Flodioxonil | 0.9980 | 0.0001-0.05 | 0.001 | Oxadiazon | 0.9981 | 0.0001-0.05 | 0.001 |
| Fluquinconazole | 0.9995 | 0.0001-0.05 | 0.001 | Oxyfluorfen | 0.9970 | 0.0005-0.05 | 0.001 |
| Fluridone | 0.9975 | 0.001-0.05 | 0.005 | Paclobutrazol | 0.9986 | 0.00025-0.05 | 0.001 |
| Flusilazole | 0.9983 | 0.000-0.05 | 0.001 | Parathion (ethyl) | 0.9974 | 0.00025-0.05 | 0.001 |
| Flutolanil | 0.9981 | 0.0001-0.05 | 0.001 | Parathion-methyl | 0.9971 | 0.001-0.05 | 0.005 |
| Flutriafol | 0.9983 | 0.0001-0.05 | 0.001 | Pebulate | 0.9996 | 0.00025-0.05 | 0.001 |
| Fluvalinate peak1 | 0.9998 | 0.00025-0.05 | 0.001 | Penconazole | 0.9984 | 0.00025-0.05 | 0.001 |
| Fluvalinate peak2 | 0.9998 | 0.00025-0.05 | 0.001 | Pendimethalin | 0.9981 | 0.0001-0.05 | 0.001 |
| Folpet | 0.9990 | 0.0005-0.05 | 0.001 | Pentachloroanline | 0.9992 | 0.0001-0.05 | 0.001 |
| Fonofos | 0.9972 | 0.0001-0.05 | 0.001 | Pentachloroanisole | 0.9988 | 0.0001-0.05 | 0.001 |
| Heptachlor | 0.9984 | 0.0001-0.05 | 0.001 | Pentachlorobenzene | 0.9991 | 0.0001-0.05 | 0.001 |
| Heptachlor epoxide | 0.9982 | 0.0025-0.05 | 0.001 | Pentachlorobenzonitrile | 0.9984 | 0.0001-0.05 | 0.001 |
| Hexachlorobenzene | 0.9994 | 0.0001-0.05 | 0.001 | Pentachlorothioanisole | 0.9992 | 0.00025-0.05 | 0.001 |
| Hexazinone | 0.9992 | 0.0025-0.05 | 0.001 | | | | |
| Iodofenfos | 0.9985 | 0.0001-0.05 | 0.001 | | | | |

* LOQ in ppm (mg/kg) unit

ตารางที่ 2 ขีดความสามารถในการตรวจวัดสารกำจัดศัตรูพืชตกค้างในแอปเปิล (ต่อ)

| Compound | R ² | Range | LOQ | Compound | R ² | Range | LOQ |
|--------------------|----------------|--------------|-------|------------------------------|----------------|--------------|-------|
| Cis-permethrin | 0.9999 | 0.00025-0.05 | 0.001 | Quinalphos | 0.9974 | 0.0005-0.05 | 0.001 |
| Trans-permethrin | 0.9990 | 0.00025-0.05 | 0.001 | Quintozene | 0.9973 | 0.0001-0.05 | 0.001 |
| Perthane (Ethylan) | 0.9994 | 0.0001-0.05 | 0.001 | Resmethrin Peak1 | 0.8109 | 0.005-0.05 | - |
| Phenothrin | 0.9995 | 0.001-0.05 | 0.005 | Resmethrin Peak2 | 0.9989 | 0.001-0.05 | 0.005 |
| Phorate | 0.9972 | 0.00025-0.05 | 0.001 | Sulfotep | 0.9980 | 0.0001-0.05 | 0.001 |
| Phosalone | 0.9998 | 0.0001-0.05 | 0.001 | Sulprofos | 0.9984 | 0.0001-0.05 | 0.001 |
| Phosmet | 0.9993 | 0.00025-0.05 | 0.001 | Tebuconazole | 0.9992 | 0.0001-0.05 | 0.001 |
| Phthalimide | 0.9976 | 0.005-0.500 | 0.010 | Tebufenpyrad | 0.9992 | 0.0001-0.05 | 0.001 |
| Piperonyl butoxide | 0.9987 | 0.0001-0.05 | 0.001 | Tecnazene | 0.9991 | 0.0001-0.05 | 0.001 |
| Pirimiphos-ethyl | 0.9986 | 0.0001-0.05 | 0.001 | Tefluthrin | 0.9982 | 0.0001-0.05 | 0.001 |
| Pirimiphos-methyl | 0.9994 | 0.0001-0.05 | 0.001 | Terbacil | 0.9987 | 0.0001-0.05 | 0.001 |
| Pretilachlor | 0.9986 | 0.0001-0.05 | 0.001 | Terbufos | 0.9970 | 0.0001-0.05 | 0.001 |
| Prochloraz | 0.9996 | 0.001-0.05 | 0.005 | Terbutylazine | 0.9995 | 0.00025-0.05 | 0.001 |
| procymidone | 0.9983 | 0.00025-0.05 | 0.001 | Tetrachlorvinphos | 0.9989 | 0.0001-0.05 | 0.001 |
| Prodiamine | 0.9966 | 0.0005-0.05 | 0.001 | Tetradifon | 0.9992 | 0.0005-0.05 | 0.001 |
| Profenofos | 0.9976 | 0.00025-0.05 | 0.001 | Tetrahydrophthalimide (THPI) | 0.9989 | 0.0025-0.500 | 0.001 |
| Profluralin | 0.9958 | 0.0005-0.05 | 0.001 | Tetramethrin Peak1 | 0.9988 | 0.001-0.05 | 0.005 |
| Propachlor | 0.9988 | 0.0001-0.05 | 0.001 | Tetramethrin Peak2 | 0.9980 | 0.00025-0.05 | 0.001 |
| Propanil | 0.9981 | 0.0005-0.05 | 0.001 | Tolclofos-methyl | 0.9981 | 0.00025-0.05 | 0.001 |
| Propargite | 0.9963 | 0.001-0.05 | 0.005 | Tolyfluand | 0.9986 | 0.0001-0.05 | 0.001 |
| Propisochlor | 0.9982 | 0.0005-0.05 | 0.001 | Transfluthrin | 0.9979 | 0.00025-0.05 | 0.001 |
| Prothiofos | 0.9989 | 0.00025-0.05 | 0.001 | Triadimefos | 0.9991 | 0.00025-0.05 | 0.001 |
| Propyzamide | 0.9985 | 0.00025-0.05 | 0.001 | Triadimenol | 0.9994 | 0.0005-0.05 | 0.001 |
| Pyraclofos | 0.9992 | 0.0005-0.05 | 0.001 | Triallate | 0.9988 | 0.0005-0.05 | 0.001 |
| Pyrazophos | 0.9999 | 0.00025-0.05 | 0.001 | Triazophos | 0.9979 | 0.00025-0.05 | 0.001 |
| Pyridaben | 0.9983 | 0.0001-0.05 | 0.001 | Triflumizole | 0.9966 | 0.0005-0.05 | 0.001 |
| Pyridaphenthion | 0.9998 | 0.0005-0.05 | 0.001 | Trifluralin | 0.9973 | 0.0005-0.05 | 0.001 |
| Pyrimethanil | 0.9993 | 0.000-0.05 | 0.001 | Triphenylphosphate | - | ISTD | - |
| Pyriproxyfen | 0.9990 | 0.0001-0.05 | 0.001 | Vinclozolin | 0.9976 | 0.0001-0.05 | 0.001 |

* LOQ in ppm (mg/kg) unit

ติดตามแอปพลิเคชันอื่น ๆ ได้ที่ <https://www.scispec.co.th>



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