

溶劑萃取果樹葉片葉綠素之研究¹

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摘 要

利用研磨萃取葉片葉綠素需經過許多步驟，研磨過程亦會造成損耗。本研究以85%丙酮、95%乙醇、DMF及DMSO等四種溶劑，在未經研磨步驟下萃取10種果樹葉片之葉綠素。由結果顯示不同溶劑萃取之效果並不相同，且四種溶劑經48小時萃取並不能由葉片完全萃取出葉綠素。比較四種溶劑，80%丙酮之萃取百分率均較另三種溶劑低，而DMF經過48小時之萃取，在葡萄、梨、番石榴、芒果、麻豆文旦及蓮霧等6種果樹葉片萃取百分率最高，而95%乙醇在桃及枇杷萃取百分率最高。龍眼及荔枝經48小時萃取百分比都在85%以下，並不適合在未經研磨的情況下萃取葉片之葉綠素，但DMSO是四種溶劑中對龍眼及荔枝葉片葉綠素萃取百分率最高者。

關鍵字：葉綠素、萃取、溶劑。

前 言

在植物生理過程葉綠體扮演重要的角色，其吸收光能以供光合成反應利用⁽¹⁴⁾，葉綠素含量與光合成速率成正相關⁽¹⁰⁾，此外當植物受到逆境時會降低葉綠素含量⁽⁹⁾，因此葉片葉綠素含量可用來作為植物生理狀況指標之一。雖然近年來利用非破壞性葉綠素含量測定方法極為普遍，但現有利用之儀器仍有部分限制，諸如欲建立可信度高之標準線需增加取樣數⁽²⁾，而葉片厚度及形態構造亦影響非破壞性葉綠素含量測定方法之準確性。

Argon⁽⁴⁾以組織研磨萃取葉綠素，此後許多方法大多遵循此方式，但為減少萃取過程之步驟及消耗，Hiscox及Israelstam⁽⁷⁾以DMSO在65°C下未經研磨萃取松葉、天竺葵、檸檬及豌豆成熟葉片葉綠素，效果與丙酮研磨後萃取相似，但可節省許多萃取之步驟。可被利用於萃取葉綠素之溶劑有多種，張等人⁽¹⁾比較DMF、DMSO及丙酮三種溶劑萃取經研磨後樟樹葉片，結果萃取效果以DMF最佳，丙酮次之，而DMSO最差，相同萃取時間所萃取葉綠素含量最低。Inskeep與Bloom⁽⁸⁾比較80%丙酮與DMF之萃取效果發現DMF可有效完全萃取葉綠素，萃取液之安定性較佳，分析時誤差少亦簡便。Alpert⁽³⁾則利用DMSO萃取蘚類之葉綠素其效果較丙酮佳，但其萃取液安定性並未較丙酮萃取液安定，Knudson等⁽⁹⁾試驗結果在黃豆葉片未研磨時丙酮萃取效果低於乙醇。由前人之研究結果顯示，相同溶劑針對不同植物葉片的萃取效果並不一致，亦未呈一定之趨勢。

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本試驗之目的為比較不同的溶劑在葉片未經研磨之下，何者可由果樹葉片快速並較完全萃取出較高百分率葉綠素，以提供日後測定果樹葉片葉綠素含量之參考。

材料及方法

一、材料及分析方法

取葡萄、梨、桃、番石榴、荔枝、芒果、麻豆文旦、龍眼、蓮霧、枇杷等成熟、完整、無病蟲害且葉色一致之8片葉片，拭淨後以打孔器取下3片直徑0.6mm之葉圓片。同一葉片取下之葉圓片分置不同溶液並加以編號，分別用3 ml 95%乙醇、80%丙酮、DMF (N, N-Dimethylformamide, 廠牌Merck)及DMSO(dimethylsulphoxide, 廠牌Merck)純液中，以鋁箔紙包覆在室溫下萃取24小時後以分光儀(spectrophotometer, HITACHI U-3000型)測量特定之吸光值，再將葉圓片取出置於另一試管加入3ml萃取液24小時後再重複測定吸光值，葉原圓片取出加入相同溶劑3 ml，隨即在冰水浴下以研磨機(Polytron, 型號PT-3100)研磨，再以離心機離心(3000 rpm) 10分鐘後再測萃取液之吸收值，將三次之萃取量加總計算為葉片之總葉綠素、葉綠素 a 及葉綠素 b 之含量，再計算各不同時間萃取之百分率。

二、葉綠素含量計算

- (一)以丙酮為溶劑係參考Argon⁽³⁾及Argon等人⁽⁴⁾所述方法，測定663及645 nm之吸收值，以下列公式計算葉綠素量，葉綠素 a (mg/ml) = $(12.7A_{663} - 2.69A_{645})$ 、葉綠素 b (mg/ml) = $(22.9A_{645} - 4.68A_{663})$ 及葉綠素總量(mg/ml) = $(20.2A_{645} + 8.02A_{663})$ 。
- (二)以乙醇為溶劑計算方法係參考Knudson等人⁽⁹⁾之公式，測定663及645 nm之吸收值，計算葉綠素 a ($\mu\text{g/ml}$) = $13.7A_{665} - 5.76A_{649}$ 、葉綠素 b ($\mu\text{g/ml}$) = $25.8A_{649} - 7.60A_{665}$ 及葉綠素總量為葉綠素 a 與葉綠素 b 相加總和。
- (三)以DMF (N, N-Dimethylformamide)為萃取溶劑時，其葉綠素含量計算方法係測定664.5及647 nm之吸收值，參考Inskeep及Bloom⁽⁸⁾建議之公式計算，葉綠素 a ($\mu\text{g/ml}$) = $12.70A_{664.5} - 2.79A_{647}$ 、葉綠素 b ($\mu\text{g/ml}$) = $20.70A_{647} - 4.62A_{664.5}$ 及葉綠素總量($\mu\text{g/ml}$) = $17.90A_{647} + 8.08A_{664.5}$ 。
- (四)以DMSO(dimethyl sulphoxide)為萃取溶劑時，其葉綠素含量計算方法係參考下列Barnes等人⁽⁶⁾之公式，測定664.9及648.2 nm之吸收值，葉綠素 a ($\mu\text{g/ml}$) = $14.85A_{664.9} - 5.14A_{648.2}$ 、葉綠素 b ($\mu\text{g/ml}$) = $25.48A_{648.2} - 7.36664.9$ 及葉綠素總量($\mu\text{g/ml}$) = $7.49664.9 + 20.34A_{648.2}$ 。

結 果

葡萄葉片葉綠素萃取之結果如表一，前24小時以DMF及DMSO萃取百分率較高，DMF萃取94.9%之總葉綠素，而DMSO萃取89.7%，80%丙酮萃取效果最差，僅萃取20.2%，而乙醇萃取69.5%，以丙酮萃取之樣品在48小時之後研磨萃取仍有73.4%之總葉綠素被萃取，前48小時DMF可萃取98%之葉綠素，是4種溶劑中萃取百分率最高者。

表一、不同溶劑對葡萄葉片葉綠素萃取之比較

Table 1. Comparison of different solvents on chlorophyll extraction in grapevine leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 20.9 ^{1c} | 10.6d | 20.2d | 6.6b | 1.7b | 5.5b | 72.5a | 87.8a | 73.4a |
| 95% ethanol | 70.0 b | 69.2c | 69.5c | 17.7a | 11.7a | 16.3a | 12.4b | 19.2b | 14.2b |
| DMF | 95.0 a | 94.8a | 94.9a | 3.5c | 2.3b | 3.1c | 1.5c | 2.9c | 2.0d |
| DMSO | 93.7 a | 78.6b | 89.7b | 2.5c | 2.1b | 2.4c | 3.8d | 19.3d | 8.0c |

¹: Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

梨葉片葉綠素之萃取結果如表二，利用95%乙醇與DMF及DMSO萃取之效果相近，分別為92.4%、94.9%及93.9%，而80%丙酮萃取之效果最差，前24小時僅萃取25.1%，在萃取48小時之後研磨萃取仍有71.3%之總葉綠素。前48小時未經研磨情況之下，DMF可萃取99%之總葉綠素，是四種溶劑中最高者，而DMSO萃取97.4%次之，但和DMF呈顯著差異。

表二、不同溶劑對梨葉片葉綠素萃取之比較

Table 2. Comparison of different solvents on chlorophyll extraction in pear leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 25.1 ^{1b} | 25.6c | 25.1c | 3.6c | 3.7a | 3.6c | 71.3a | 70.8a | 71.3a |
| 95% ethanol | 93.0 a | 91.3b | 92.4b | 5.3a | 3.5b | 4.7a | 1.7b | 5.2b | 3.0b |
| DMF | 95.0 a | 94.7a | 94.9a | 4.5b | 3.7a | 4.2b | 0.6c | 1.6c | 1.0c |
| DMSO | 94.9 a | 91.0b | 93.9a | 3.5c | 3.8a | 3.6c | 1.6b | 5.3b | 2.6b |

¹: Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

桃葉片萃取結果如表三，與梨之結果相近，前24小時，DMF、乙醇與DMSO萃取之量較多，分別為95.6%、95%及93.6%，而丙酮在前24小時萃取百分比僅有15.5%，在萃取48小時之後再研磨萃取仍有總量83%之葉綠素，前48小時以95%乙醇萃取98.7%及 DMF萃取98.4%，是萃取百分率較高者，二種溶劑間並無顯著差異。

番石榴萃取之結果如表四，以DMF前24小時萃取為93.7%最高，DMSO萃取量為91.5%次之，95%乙醇萃取百分比為89.5%，而丙酮萃取量僅有42.9%。丙酮萃取48小時之後研磨萃取，仍有43.7%之總葉綠素，經48小時DMF則可萃取98.3%之總葉綠素，是萃取百分率最高者，與其他溶劑呈顯著差異。

荔枝萃取結果如表五，四種溶劑在未經研磨萃取荔枝葉片葉綠素百分率均低，在經過48小時萃取之後再研磨萃取，雖以DMSO萃取百分率最低，但仍高達46.8%，而另三組萃取48小時均未萃取超過50%之總葉綠素。

表三、不同溶劑對桃葉片葉綠素萃取之比較

Table 3. Comparison of different solvents on chlorophyll extraction in peach leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 15.1 ¹ b | 16.7c | 15.5c | 1.4c | 1.9c | 1.5c | 83.5a | 81.5a | 83.0a |
| 95% ethanol | 94.7 a | 95.5a | 95.0a | 4.5a | 2.3b | 3.8a | 0.8c | 2.3c | 1.3c |
| DMF | 96.0 a | 94.8a | 95.6a | 3.0b | 2.6b | 2.9b | 1.0c | 2.6c | 1.6c |
| DMSO | 94.6 a | 90.2b | 93.6b | 3.6b | 3.9a | 3.7a | 1.8b | 5.9b | 2.8b |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

表四、不同溶劑對番石榴葉片葉綠素萃取之比較

Table 4. Comparison of different solvents on chlorophyll extraction in guava leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 43.8 ¹ c | 40.8c | 42.9c | 15.0a | 9.5a | 13.4a | 41.2a | 49.7a | 43.7a |
| 95% ethanol | 91.1 b | 86.6b | 89.5b | 6.3b | 5.1b | 5.8b | 2.6b | 8.3b | 4.7b |
| DMF | 94.2 a | 92.9a | 93.7a | 4.6c | 4.6c | 4.6b | 1.2c | 2.5c | 1.7d |
| DMSO | 93.1 a | 87.5b | 91.5b | 5.2c | 4.2c | 4.9b | 1.7c | 8.3b | 3.6c |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

表五、不同溶劑對荔枝葉片葉綠素萃取之比較

Table 5. Comparison of different solvents on chlorophyll extraction in litchi leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 37.1 ¹ b | 30.9b | 35.3b | 14.5a | 11.8b | 13.7b | 48.4b | 57.2b | 50.9b |
| 95% ethanol | 34.8 bc | 29.3bc | 33.1bc | 16.7a | 14.3a | 16.0a | 48.5b | 56.4b | 50.9b |
| DMF | 32.4 c | 27.3c | 31.1c | 7.7b | 4.5c | 7.0c | 59.8a | 68.2a | 61.9a |
| DMSO | 46.5 a | 39.0a | 45.3a | 8.7b | 3.9c | 7.9c | 44.7c | 57.1b | 46.8c |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

芒果利用不同溶劑萃取葉綠素之結果如表六，DMF萃取之效果最佳，前24小時萃取90%、48小時為95.8%之總葉綠素，而丙酮僅萃取39.8%，經48小時萃取之後研磨，仍有高達46%的葉綠素被萃取。乙醇萃取效果亦不佳，前24小時僅萃取65.6%之葉綠素，經萃取48小時後研磨，仍有20.5%之總葉綠素被萃取。

麻豆文旦利用不同溶劑萃取之結果如表七，經24小時之萃取，DMF萃取88.2%之總葉綠素最高，95%乙醇84.1次之，而DMSO萃取僅75.4%最低。萃取48小時之後研磨萃取，以80%丙酮仍有11.6%最高，DMSO為8.8%，而95%乙醇為4.3%及DMF3.6%較低，兩者間並無顯著差異。

表六、不同溶劑對芒果葉片葉綠素萃取之比較

Table 6. Comparison of different solvents on chlorophyll extraction in mango leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 47.7 ¹ d | 26.2d | 39.8d | 17.1a | 8.9b | 14.1a | 35.2a | 64.9a | 46.1a |
| 95% ethanol | 68.0 c | 59.3c | 65.6c | 15.2b | 10.5a | 13.9a | 16.9b | 30.2b | 20.5b |
| DMF | 90.9 a | 88.1a | 90.0a | 6.1d | 5.2d | 5.8c | 3.0d | 6.7d | 4.2d |
| DMSO | 84.4 b | 79.2b | 82.6b | 8.3c | 6.9c | 8.0b | 7.3c | 13.8c | 9.4c |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

表七、不同溶劑對麻豆文旦葉片葉綠素萃取之比較

Table 7. Comparison of different solvents on chlorophyll extraction in mato pummelo leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 83.7 ¹ b | 79.2b | 82.2b | 6.7d | 5.2d | 6.2d | 9.5a | 15.6a | 11.6a |
| 95% ethanol | 83.5 b | 85.1a | 84.1b | 13.0b | 8.9b | 11.6b | 3.5c | 6.0c | 4.3c |
| DMF | 89.4 a | 86.4a | 88.2a | 9.2c | 6.5c | 8.2c | 1.4d | 7.1c | 3.6c |
| DMSO | 75.3 c | 76.1c | 75.4c | 17.3a | 11.9a | 15.8a | 7.4b | 11.9b | 8.8b |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

龍眼萃取之萃取結果如表八，利用溶劑萃取24小時，以DMSO萃取百分比最高，但僅79.6%，經48小時之後研磨萃取，仍有14.7%之量，另三種溶劑均高達31%以上，顯示龍眼葉片為經研磨的情況之下，不適於利用上述四種溶劑萃取。

表八、不同溶劑對龍眼葉片葉綠素萃取之比較

Table 8. Comparison of different solvents on chlorophyll extraction in longan leaf

| Solvents | Percent of extract for 24 hrs | | | Percent of re-extract during 24-48 hrs | | | Percent of grind extract after 48 hrs extracted | | |
|-------------|-------------------------------|--------------|-----------|--|--------------|-----------|---|--------------|-----------|
| | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl | Chl <i>a</i> | Chl <i>b</i> | Total chl |
| 80% acetone | 57.6 ¹ b | 57.3b | 57.5b | 12.1b | 9.4b | 11.3b | 30.3c | 33.3c | 31.2c |
| 95% ethanol | 31.1 d | 21.3d | 27.9d | 18.9a | 12.1a | 16.6a | 50.0a | 66.7a | 55.5a |
| DMF | 47.8 c | 43.9c | 46.7c | 11.3b | 11.5a | 11.3b | 40.9b | 44.6b | 42.0b |
| DMSO | 81.4 a | 74.6a | 79.6a | 5.9c | 4.9c | 5.6c | 12.7d | 20.4d | 14.7d |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

蓮霧葉片葉綠素含量利用不同溶劑萃取結果如表九，萃取24小時之後以DMF萃取百分率最高達90.7%，其次為DMSO為83.1%，而80%丙酮萃取量僅有58.5%，萃取48小時之後研磨萃取，80%丙酮萃取仍有26.8%，95%乙醇為13.0%，DMSO為7.1%，而DMF僅有4.3%，並與其他溶劑呈顯著性差異。

枇杷葉片萃取結果如表十，95%乙醇、DMF及DMSO三種溶劑萃取24小時之後萃取量均在92.5%以上，以DMSO最高93.5%，DMF亦達93.4%，而80%丙酮萃取量僅有22.6%，與其他三種溶劑差距相當大，經萃取48小時之後再研磨萃取，95%乙醇萃取量僅有1.8%，與DMF及DMSO之2.5%及2.3%已呈顯著差異，而80%丙酮則高達70.3%。

表九、不同溶劑對蓮霧葉片葉綠素萃取之比較

Table 9. Comparison of different solvents on chlorophyll extraction in wax-apple leaf

| Solvents | Percent of extract for 24hrs | | | Percent of re-extract during 24-48hrs | | | Percent of grind extract after 48hrs extracted | | |
|-------------|------------------------------|-------|-----------|---------------------------------------|-------|-----------|--|-------|-----------|
| | Chl a | Chl b | Total chl | Chl a | Chl b | Total chl | Chl a | Chl b | Total chl |
| 80% acetone | 60.8 ¹ d | 53.2d | 58.5d | 15.5a | 12.7a | 14.7a | 23.6a | 34.1a | 26.8a |
| 95% ethanol | 73.7 c | 67.0c | 71.6c | 16.5a | 12.8a | 15.4a | 9.7b | 20.2b | 13.0b |
| DMF | 92.7 a | 86.9a | 90.7a | 5.2c | 4.6c | 5.0c | 2.1d | 8.5d | 4.3d |
| DMSO | 85.8 b | 78.4b | 83.1b | 9.2b | 10.4b | 9.7b | 5.1c | 11.2c | 7.1c |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

表十、不同溶劑對枇杷葉片葉綠素萃取之比較

Table 10. Comparison of different solvents on chlorophyll extraction in loquat leaf

| Solvents | Percent of extract for 24hrs | | | Percent of re-extract during 24-48hrs | | | Percent of grind extract after 48hrs extracted | | |
|-------------|------------------------------|-------|-----------|---------------------------------------|-------|-----------|--|-------|-----------|
| | Chl a | Chl b | Total chl | Chl a | Chl b | Total chl | Chl a | Chl b | Total chl |
| 80% acetone | 22.2 ¹ b | 23.4c | 22.6b | 7.8a | 5.6a | 7.1a | 70.0a | 71.0a | 70.3a |
| 95% ethanol | 92.0a | 93.5a | 92.5a | 6.6b | 4.1b | 5.7b | 1.4b | 2.4c | 1.8c |
| DMF | 94.1a | 92.3a | 93.4a | 4.6c | 3.4c | 4.1c | 1.3b | 4.3b | 2.5b |
| DMSO | 94.6a | 90.6b | 93.5a | 4.0c | 4.7b | 4.2c | 1.4b | 4.7b | 2.3b |

¹:Means with the same letter in a column are not significantly different by Duncan's multiple range test at 5% level.

討 論

Svec (1991)認為並沒有任何單一或混合的溶劑可快速並且不改變數量由葉片移出色素，本研究調查結果亦相同，四種溶劑經48小時萃取之後研磨，仍可萃取出葉綠素。而比較溶劑萃取葉綠素之效果並不容易，其原因在於葉片生長不一致性，即使同一葉片些微結構仍可能不同，造成葉片中葉綠素含量的差異。本試驗為瞭解不同溶劑萃取果樹葉片葉綠素效果之差異，在同一葉片取樣分置不同溶劑，除可使樣品中葉綠素含量儘可能一致外，萃取後經定量比較其萃取百分比，再移置新溶劑中，可減少溶劑揮發造成吸收值之誤差。

Knudson等人⁽⁹⁾試驗結果發現丙酮在黃豆葉片未研磨時萃取效果低於乙醇，其原因可能是丙酮具有高度揮發性，本研究調查10種果樹之結果，80%丙酮萃取24小時及48小時之萃取百分率均較95%乙醇、DMF及DMSO低。Moran及Porath⁽¹¹⁾以DMF萃取整個胡瓜子葉之葉綠素，發現DMF在葉綠素含量較低時極為有效，在與丙酮比較組織研磨與否對萃取量之影響

時，以DMF進行萃取無論研磨與否其值都接近，但丙酮未進行研磨者其值相差很大，與本研究之結果相近。Hiscox與Israelstam⁽⁷⁾證實利用培養器(incubator)以DMSO萃取裸子植物及被子植物葉綠素之效果與丙酮相同，且以DMSO萃取液之安定性較佳，惟萃取之時間較長。Alpert調查結果認為不同的蘚類萃取之時間皆不同，但以DMSO萃取液並不較丙酮穩定⁽³⁾。但Barnes等人⁽⁶⁾重新評估DMSO對8種地衣及10高等植物葉綠素萃取之效果，認為與80%丙酮得到相似的結果，可完全萃取葉綠素a及葉綠素b。但Shinano等人⁽¹³⁾比較萃取竹、橡樹、小麥及野生菜豆葉片之葉綠素，認為葉片物理及形態特性是影響萃取效果之重要因子。由前人之研究結果，不同溶劑在不同植物葉片中萃取的效果並不相同，本試驗亦未呈一致之趨勢且差異甚大。

本研究之四種溶劑調查結果，80%丙酮萃取百分率均較另三種溶劑低，DMF經過48小時之萃取，在葡萄、梨、番石榴、芒果、麻豆文旦及蓮霧等6種果樹葉片萃取百分率最高，而95%乙醇萃取百分率最高有桃及枇杷，但在桃以95%乙醇與DMF二者間並未呈顯著差異。龍眼及荔枝經48小時萃取百分比都在85%以下，並不適合在未經研磨的情況下以上述四種溶劑萃取葉片之葉綠素，但DMSO是四種溶劑中對龍眼及荔枝葉片葉綠素萃取百分率最高者。

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Studies on the Extraction of Chlorophyll in Fruit Tree Leaves with Different Solvents¹

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ABSTRACT

It takes many steps to extract the leaf chlorophyll by means of grinding method, and it will get loss in each procedure. In this study, 4 solvents, 85% acetone, 95% ethanol, DMF and DMSO, were used to extract the leaf chlorophyll without grinding in 10 fruit trees. The results showed that different solvents had different extraction effects, but the chlorophyll could not be completely extracted from the leaf by all these four solvents for 48 hours. In comparison of these four solvents, the extraction rate of 80% acetone was lower than the other three solvents. The extraction rates in grape, pear, guava, mango, mato pummelo and wax-apple were the highest that extracted in DMF for 48 hours, and the extraction rates in peach and loquat were the highest that extracted in 95% ethanol. The extraction rates were below 85% in longan and litchi that extracted for 48 hours, this result revealed that it was unsuitable to extract the leaf chlorophyll without grinding. But among four solvents, DMSO had the highest extraction rate for longan and litchi.

Key words: chlorophyll, extraction, solvents.

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