

摘要

本研究首先探討 HPLC 層析方法與樣品製備對蔬菜中類胡蘿蔔素定量之影響，結果指出梯度沖提系統的層析方法較佳，可於 45 min 內分析出 13-cis lutein、13?-cis lutein、all-trans lutein、9-cis lutein、9?-cis lutein、all-trans zeaxanthin、9-cis zeaxanthin、13-cis β -carotene、all-trans β -carotene 及 9-cis β carotene 等 10 種順/反異構物；樣品的製備則採用樹脂皂化法來進行，以去除分析的干擾物質如葉綠素等。其次，以上述建立的方法調查省產 25 種蔬菜中葉黃素、玉米黃素及 β -胡蘿蔔素的含量分布，其中以香菜、九層塔、地瓜葉與油菜 4 種蔬菜之總全反式類胡蘿蔔素含量較高，分別為 104.76、83.68、75.96 與 62.32 $\mu\text{g/g}$ fresh vegetables。之後再探討此 4 種蔬菜在經水煮、油炒和油炸等熱加工處理後對其類胡蘿蔔素含量之影響，當以類胡蘿蔔素總含量來看，水煮蔬菜損失最少且沒有顯著差異 ($p > 0.05$)，油炒蔬菜損失 14.75 ~ 33.69 %，油炸九層塔損失最多；降低 36.97 %。於是進一步探討水煮時間對上述 4 種蔬菜中類胡蘿蔔素及總酚含量之影響；類胡蘿蔔素方面，隨水煮時間增長，總類胡蘿蔔素含量先增後減，香菜、九層塔、地瓜葉與油菜分別在水煮 10、5、5 與 5 min 時達最高，與新鮮蔬菜相比增加了 27.30、34.88、15.72 與 7.27 %；總酚含量方面，香菜和油菜隨水煮時間增加而減少，九層塔與地瓜葉則各於水煮 1 與 5 min 時達最高，分別增加了 14.66 與 30.61 %。最後探討水煮時間對四種蔬菜之抗氧化活性之影響；在 Trolox 當量抗氧化能力 (TEAC) 方面，與新鮮蔬菜相比，香菜經水煮 1 min 後其 TEAC 值顯著提升 7.53 %，九層塔與地瓜葉經水煮 5 min，則分別提升 3.76 % 與 7.59 %，而油菜之 TEAC 值則隨水煮時間增加而遞減，與其總酚含量的變化趨勢相符；在抑制脂質過氧化率 (IP %) 方面，香菜經水煮 10 min，九層塔、地瓜葉與油菜則經水煮 5 min，其 IP % 達到最高；分別為 86.71、73.56、67.51 及 14.23 %，與其總類胡蘿蔔素含量成正相關；螯合亞鐵離子能力則是以經水煮 1 min 之香菜、九層塔與地瓜葉，及經 5 min 水煮之油菜最佳，分別為 98.10、92.74、91.46 及 88.29 %。不過隨著水煮時間的繼續增加，4 種蔬菜之所有抗氧化活性皆隨之遞減。由以上結果顯示，經適當程度的水煮，可有效提升蔬菜之類胡蘿蔔素與總酚含量進而增加其抗氧化活性，但過度水煮，由於類胡蘿蔔素與總酚被破壞反而降低其所有抗氧化活性。

關鍵字：類胡蘿蔔素、葉黃素、玉米黃素、 β -胡蘿蔔素、熱加工、抗氧化活性

Abstract

At the beginning of this study, the effects of HPLC analysis methods and sample preparation methods on carotenoids quantification in vegetables were evaluated. Because of less time required for carotenoids analysis in HPLC, gradient elution system was better than isocratic elution system. The former could analysis ten cis/trans isomers including 13-cis lutein, 13[?]-cis lutein, all-trans lutein, 9-cis lutein, 9[?]-cis lutein, all-trans zeaxanthin, 9-cis zeaxanthin, 13-cis β -carotene, all-trans β -carotene and 9-cis- β carotene within 45 min. Three sample preparation methods were also compared. Resin saponification method was selected due to its ability to remove interfering substances such as chlorophylls. Base on the above established methods, 25 kinds of fresh vegetables in Taiwan were analyzed their carotenoid concentration including all-trans lutein, zeaxanthin and β -carotene. The result indicated that parsly, basil, sweet potato leaf, and rape contained higher total carotenoids content, which were 104.76, 83.68, 75.96, and 62.32 $\mu\text{g/g}$ fresh vegetables respectively. Therefore, these vegetables were employed to evaluate the effects of boiled, stir-fried and deep-fried on carotenoids. By comparison of total carotenoids, there was no significantly difference loss ($p > 0.05$) as fresh vegetable was boiled for 1 min. Whereas, Stir-fried of vegetables and deep-fried of basil resulted in 14.75~ 33.69% loss and 36.97% loss, respectively. These four vegetables were further evaluated the effects of boiling time on carotenoids and total phenolic compounds (TPC). It was found that parsly, basil, sweet potato leaf, and rape were boiled for 10, 5, 5 and 5 min, resulted in 27.30, 34.88, 15.72 and 7.27% increases in total carotenoids content, respectively, as compared with each fresh vegetable. It was also found the decrease of TPC content in parsly and rape when the boiling time continued to increase. Whereas, boiling for 1 and 5 min increased the TPC content of basil and sweet potato leaf up to 14.66 and 30.61 %, respectively. Finally, these four vegetables were also evaluated the effects of boiling time on antioxidant activity. Boiling had found to enhance trolox equivalent antioxidant capacity (TEAC) in vegetables. Boiling for 1 min significantly increased TEAC value of parsly up to 7.53% as compared to that found in fresh parsly. Basil and sweet potato leaf were boiled for 5 min increased TEAC up to 3.76 and 7.59 %, respectively. Nevertheless, TEAC of rape was decreased when the boiling time continued to

increase. Compared TEAC and TPC content, they had the similar tendency. This change in inhibition of peroxidation (IP %) occurred during boiling. It was found parsley, basil, sweet potato leaf and rape were boiled for 10, 5, 5 and 5 min, had higher level of IP%, which were 86.71, 73.56, 67.51 and 14.23%, respectively. Compared IP% and total carotenoids content, they had the similar tendency. Chelating effects had been observed during boiling. Parsley, basil, sweet potato leaf and rape had higher level of chelating effects when they were boiled for 1, 1, 1 and 5min, which were 98.10, 92.74, 91.46 and 88.29 %, respectively. However, the boiling time continued to increase, caused the decrease in total antioxidant activity of these four vegetables. These result showed that suitable boiling increased the carotenoids content, TPC and antioxidant activity, but over boiling decreased them.

Keywords: carotenoids; lutein; zeaxanthin; β -carotene; thermal processing; antioxidant activity