

Total Phenolic Contents and Antioxidant Activity in Sweet Potato Leaves and Carrots after Steam-Cooking

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Abstract

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Vegetables serve as an important source of natural antioxidants owing to the presence of phenolic compounds, which provide health benefits. In this study, we investigated the effect of steam-cooking on the total phenolic contents (TPC) and antioxidant activity, as assessed by oxygen radical absorbance capacity (ORAC), in sweet potato leaves (SPL) and carrots (CA). The results revealed an increase in TPC and antioxidant activity in the steamed stems and leaves of SPL. However, while TPC and antioxidant activity increased in the steamed peel of CA, there was a slight decrease in the steamed flesh of CA. A positive correlation was observed between TPC and antioxidant activity. According to the study, it is suggested that employing a suitable steam-cooking process could serve as a preferable method to enhance or preserve the TPC and antioxidant activity of SPL and CA. Further research is needed to elucidate the role of individual bioactive components influencing the antioxidant properties of SPL and CA.

Key words: Sweet potato leaves, Carrot, Total phenolic contents, Antioxidant activity.

The consumption of vegetables plays an important role in maintaining our body's health. Vegetables act as a good source of natural antioxidants due to the occurrence of phenolic compounds, such as flavonoids and phenolic acids (Donglin & Hamazu 2004). The antioxidant properties of these compounds contribute to the reduction of oxidative stress, thus aiding in the prevention of chronic diseases (Muscolo *et al.* 2024). Most vegetables are cooked before consumption because cooking is an important step in obtaining safe and hygienic vegetables. Through the process of heating, vegetables undergo chemical reactions that enhance their digestibility and nutritional val-

ues. Several studies have reported that heating processes cause many changes in the chemical composition of vegetables. After cooking, the total polyphenol content (TPC) and antioxidant activity in various vegetables could either increase or decrease compared to fresh vegetables (Faller & Fialho 2009). Previous study indicated that steaming is a proper thermal processing method to preserve these phytochemicals and affect the antioxidant activity in vegetables (Palermo *et al.* 2014; Nayak *et al.* 2015).

Taiwan, being a tropical country, boasts a diverse array of vegetables. However, due to dietary preferences, most of these vegetables

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undergo cooking processes rather than being consumed raw. Despite this, there is limited information available regarding the impact of steaming on the TPC and antioxidant activity of vegetables cultivated in Taiwan. Sweet potato leaves (SPL) and carrots (CA) are among the commonly consumed leafy and root vegetables in Taiwan. It is important to understand the extent of TPC or antioxidant capacity loss in steamed vegetables compared to their levels in fresh vegetables. Therefore, the objective of this study was to evaluate the influence of steam-cooking on the TPC and antioxidant activity of various edible parts in SPL and CA.

The SPL and CA specimens were procured from a local supermarket in Kaohsiung, Taiwan. Subsequently, the leaf and stem tissues of SPL were meticulously separated using a knife, while the peel and flesh tissues of CA were delineated using a peeler and knife, respectively. All sections of total 2 kg of SPL and 2 kg of CA were diced into small pieces. One kilogram of the chopped SPL and CA was subjected to steaming over boiled water for 3 min, while the remaining portions were left uncooked. Following this, both the steamed and raw samples were dried in an oven at 55°C for 16 h and subsequently ground using a commercial grinder. Five grams of the ground powders from the peel and flesh of CA, as well as from the leaf and stem of SPL, were accurately weighed and immersed in 45 mL of distilled water for 30

min with periodic agitation. Subsequently, the samples were sonicated for 30 min at room temperature. The resultant mixtures were then subjected to centrifugation at 2,500× *g* for 10 min, following which the supernatants were collected and stored at -20°C for subsequent analysis.

The TPC of the SPL and CA extracts was determined by the Folin-Ciocalteu method (Singleton *et al.* 1999) with slight modifications. TPC values were expressed as milligram of gallic acid equivalent (GAE) per 100 g of fresh sample and are presented in Table 1. In raw SPL, the TPC in leaves was determined to be 70.48 mg GAE per 100 g fresh weight (fw), which was 2.1 times higher than that in stems. Following steaming, the TPC of SPL significantly increased to 312.21 mg GAE per 100 g fw ($P < 0.05$) compared to raw leaves. The TPC in leaf fractions of steamed SPL exhibited a 4.5-fold increase compared to raw leaves, and a significant increase was also observed in stem fractions of steamed SPL. These findings align with previous research indicating a significant increase in TPC in steamed SPL (Sun *et al.* 2014). In raw CA, the TPC in peel was measured at 27.88 mg GAE per 100 g fw, which was 1.4 times higher than that in flesh. Following steaming, the TPC in the peel increased to 45.15 mg GAE per 100 g fw, while no significant difference was observed in the TPC of CA flesh. Different tissues in different vegetables contain various compounds, some

Table 1. The total phenolic content in different raw and steamed sweet potato leaves (SPL) and carrots (CA) tissues.

Tissues of SPL and CA	Total phenolic content ^z (mg GAE 100 g ⁻¹ fresh weight)
Stem fractions of raw SPL	33.30 ± 0.39 e ^y
Stem fractions of steamed SPL	37.27 ± 1.68 d
Leaf fractions of raw SPL	70.48 ± 5.37 b
Leaf fractions of steamed SPL	312.21 ± 1.62 a
Peel fractions of raw CA	27.88 ± 0.53 f
Peel fractions of steamed CA	45.15 ± 1.52 c
Flesh fractions of raw CA	19.83 ± 0.48 g
Flesh fractions of steamed CA	16.52 ± 1.09 g

^z GAE: gallic acid equivalent.

^y Mean ± standard deviation ($n = 3$). Means within the column followed by the different letters are significantly different at $P < 0.05$ by Duncan's multiple range test.

of which are thermally resistant, and some are not; therefore, the same cooking method may have different effects on different kinds of vegetables (Bernhardt & Schlich 2006).

The antioxidant activity of SPL and CA was evaluated using the oxygen radical absorbance capacity (ORAC) assay, as described in a previous study (Ninfali *et al.* 2002). The ORAC values representing the antioxidant activity of SPL and CA are depicted in Fig. 1. The highest ORAC value was observed in leaf fractions of steamed SPL (955.72 μmol trolox equivalent (TE) 100 g^{-1} fw), while the lowest ORAC value was showed in the flesh of steamed CA (45.12 μmol TE 100 g^{-1} fw). The ORAC value in the leaf fractions of raw SPL was higher than that in the stem fractions. Steaming led to an increase in the antioxidant activity of SPL. Specifically, the ORAC value in steamed SPL leaves was 2.5 times higher than that in raw SPL leaves, which correlated with the increase in TPC. Moreover, the ORAC value was higher in the peel and lower in the flesh of both raw and steamed CA. The ORAC value in the peel increased to 145.63 μmol TE per 100 g^{-1} fw, whereas a decrease in the ORAC value was observed in the flesh of CA after steaming. The

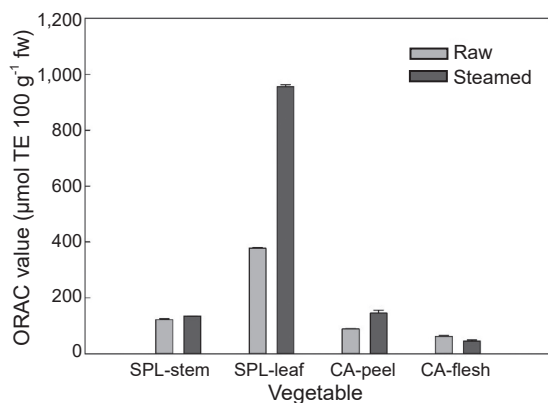


Fig. 1. The oxygen radical absorbance capacity (ORAC) value in different raw and steamed sweet potato leaves (SPL) and carrots (CA) tissues. The error bars indicate the standard deviation of triplicate analysis. TE: trolox equivalent.

ORAC values exhibited a similar pattern to the TPC in both SPL and CA tissues. The increase in TPC corresponded with the trend in antioxidant activity, suggesting that TPC might be the primary contributor to the antioxidant activity. Furthermore, the results indicated that TPC had a positive correlation with the ORAC value in both raw ($r = 0.86$) and steamed ($r = 0.99$) SPL and CA (Tables 2–3).

This study showed that steaming could enhance or maintain TPC and antioxidant activity of SPL and CA. It is suggested that utilizing an appropriate steam-cooking method may be a preferred approach to preserve the TPC and antioxidant activity of SPL and CA. Steam-cooking might impact the antioxidant activity of vegetables by facilitating the release of phenolic compounds, as heating can disrupt these structures, thereby releasing bound phenolic compounds and increasing phenolic contents (Nayak *et al.* 2015). It is possible that heating help break the cell wall and release antioxidant compounds, leading to an increase in antioxidant capacity (Choi *et al.* 2006). Nonetheless, further research is required to elucidate the role of individual bioactive components that influence the antioxidant properties of SPL and CA.

Table 2. Pearson correlation coefficients (r) between total phenolic content (TPC) and oxygen radical absorbance capacity (ORAC) value of raw sweet potato leaves (SPL) and carrots (CA).

Variables	TPC	ORAC
TPC	1	
ORAC	0.86*	1

*The correlation coefficients are significant at $P < 0.05$.

Table 3. Pearson correlation coefficients (r) between total phenolic content (TPC) and oxygen radical absorbance capacity (ORAC) value of steamed sweet potato leaves (SPL) and carrots (CA).

Variables	TPC	ORAC
TPC	1	
ORAC	0.99*	1

*The correlation coefficients are significant at $P < 0.05$.

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蒸煮甘藷葉和紅蘿蔔總酚含量與抗氧化活性

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摘要

洪千雅、蔣雅如、陳玥辰。2024。蒸煮甘藷葉和紅蘿蔔總酚含量與抗氧化活性。台灣農業研究 73(3):219–223。

蔬菜含有對身體健康有益的酚類化合物，也是天然抗氧化劑的重要來源。本研究初步探討蒸煮加熱對甘藷葉與紅蘿蔔的總酚含量及抗氧化活性的影響。試驗結果顯示，甘藷葉經蒸煮後，其莖、葉的總酚含量與抗氧化活性均有所增加；而紅蘿蔔在蒸煮後，紅蘿蔔皮的總酚含量與抗氧化活性皆增加，但在果肉部分則略微降低。甘藷葉與紅蘿蔔的總酚含量及抗氧化活性間存在正相關性。因此，根據試驗結果，採用適當的蒸煮方法有助於提升或保持甘藷葉與紅蘿蔔的總酚含量及抗氧化活性。有關影響甘藷葉與胡蘿蔔抗氧化活性的個別生物活性成分，則有待進一步探討。

關鍵詞：甘藷葉、紅蘿蔔、總酚含量、抗氧化活性。

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