Original Article

Fruits and stir-fried vegetables increase plasma carotenoids in young adults

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We examined the plasma levels of carotenoids in young adults after a dietary intervention composed of increased intakes of fruits and stir-fried vegetables from a Taiwanese mixed diet. Thirty-four apparently healthy, non-smoking subjects who normally ingested less than two and a half servings of fruits and vegetables daily were selected for the study. Meals changed were lunch and dinner on weekdays for a period of 4 weeks. The test meal consisted of three servings of stir-fried vegetables and two servings of fresh fruits. Plasma carotenoid levels in subjects significantly increased from 19%-32% for β-carotene, 15%-47% for lycopene and 59%-88% for β-crytoxanthin ($p < 0.05$) from week 1 to 4. However, these concentrations of β-carotene and lycopene significantly decreased after stopping the consumption of the test meals. This study reveals the importance of a continuous consumption of carotenoid rich foods in order to maintain high levels of plasma carotenoids for the potential prevention of chronic diseases in individuals.

Key Words: fruits, stir-fried vegetables, β-carotene β-crytoxanthin, lycopene, young adults

INTRODUCTION

The five major plasma carotenoids are β-carotene, α-carotene, lycopene, lutein/ zeaxanthin, and β-cryptoxanthin, and these account for more than 90% of the circulating carotenoids in humans.[1] Carotenoids are lipid-soluble pigments found in plant foods that function as vitamin A precursors and as antioxidants.[2] A high consumption of fruits and vegetables may also be beneficial with respect to cancer, cardiovascular disease, cataracts, and age-related macular degeneration.[3-7] Relative risks are lowest for persons with plasma β-carotene concentrations in the range of 0.34 to 0.53 μmol/L, with a risk reduction for total death, cardiovascular disease, and cancer.[8] Fruits and vegetables provides antioxidant capacity from several components, for example, carotenoids, vitamin E, and vitamin C.[9] Numerous epidemiologic studies have suggested that dietary and blood carotenoids play a role in reducing the risk of cancer and chronic diseases that may be associated with the antioxidant properties of carotenoids.[10] In particular, lycopene is one of the most potent antioxidants.[11] Several studies have indicated that lycopene is an effective antioxidant and free radical scanvenger. Because of its high number of conjugated double bonds, lycopene exhibits a higher singlet oxygen-quenching ability compared to β-carotene or α-tocopherol.[12]

In two intervention trials, where there was a long history of smoking or asbestos exposure along with alcohol consumption, supplementation with 20-30 mg/day of β-carotene had a higher incidence of lung cancer than in subjects who took a placebo. Carotenoid supplementation did not produce a protective effect against this disease.[13] Results of metabolic and utilization studies of carotenoids in humans are inconsistent, but from sources of fresh fruits and vegetables, dietary and blood carotenoids levels generally produce a decreased risk of chronic disease. Therefore, it has been recommended to ingest carotenoids from fruits and vegetables rather than supplements to prevent disease. The 1993-1996 Nutrition and Health Survey in Taiwan (NAHSIT) revealed that dietary protein and fat intake of adults 20-30 years old were higher than the recommended daily intake of the Department of Health (DOH), dietary carbohydrate intake was deficient. The main sources of dietary carbohydrates in Taiwan are bread, cereals, rice, and pasta group, fruits, and vegetables. The 1993-1996 NAHSIT indicated that the daily intake of dietary vegetables was enough. Therefore, increasing consumption of bread, cereals, rice, pasta group, and fruits could increase dietary carbohydrate intake.[14] The Department of Health recommends five servings of fruits and vegetables per day.

Several factors affect the bioavailability of carotenoids. The mnemonic "SLAMENGHI" describes these factors: Species of carotenoids, Linkage at molecular level, Amount of carotenoids, Matrix, Effectors of absorption and bioconversion, Nutrients status, Genetic factors, Host-related factors and Interactions.[15,16]

Instead of eating raw vegetable as in Western-style salads, eating stir-fried vegetables is the most prevalent way of consuming vegetables in Taiwan. Some studies have

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Manuscript received 30 November 2006. Initial review completed 24 January 2007. Revision accepted 24 February 2007.

indicated that β-carotene from raw vegetable is less available than that from cooked or processed vegetables.[17]
Little is known about plasma carotenoid concentrations with the intake of mixed diets in Taiwan. The aim of the study is to examine plasma carotenoid responses after consuming a Taiwanese mixed diet for 4 weeks.

SUBJECTS AND METHODS

Subjects

After a screening history and medical examination, healthy adults (14 men, 20 women) who did not smoke or take supplements were selected for the intervention trial. The protocol was explained to the volunteers before they gave their informed consent. The major inclusion criteria were absence of the following health conditions: renal disease; cardiovascular disease; gastrointestinal tract disease; liver disease; hypertension and neurotic syndrome. Other criteria also included neither being pregnant nor lactating, no intake of prescribed medication and having an intake less than two and a half servings of fruits and vegetables per day. During the study, the physical condition of subjects was monitored and managed by a physician. The Taipei Medical University Hospital's Human Studies Board of Ethics approved the study.

Study design

Intervention periods were preceded by washout phases of a low carotenoid diet for 1 wk. The study was a 4-wk dietary intervention study, with 4-wk washout periods, resulting in a study period of 8 wk (Fig. 1). Subjects ingested the test meals at lunch and dinner for a 4-wk period, but on weekends and holiday no meals were provided. Each test meal (lunch or dinner) provided one and a half servings of stir-fried vegetables and one serving of fresh fruit. Subjects kept dietary records including of test meals and breakfast during the 8-wk study period. Subjects were instructed to avoid fruits and vegetables high in carotenoids throughout study.

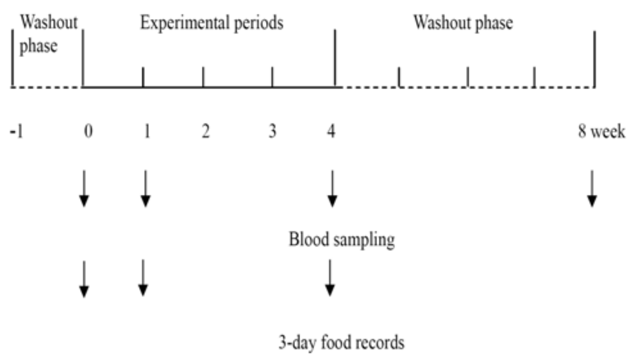

Figure 1. Experimental design.

Diets

All volunteers received the same basic diet with different energy levels according to gender. The test meals included lunch and dinner, and both test meals provided 820 and 750 kcal for males and females, respectively. For example, each test meal provided six servings from the bread/ cereals/ rice/ pasta group; two and a half servings from the meat/ poultry/ fish group; one and a half servings from the vegetable group; one serving from the fruit group, and three servings from the oil for males. Stir-fried vegetables were prepared by heating 8-10 g of soybean oil in a frying pan on a gas stove to 240 ^{0}C. For females, each test meal had one less serving from the bread/ cereals/ rice/ pasta group than for males. The percentages of energy from protein, fat, and carbohydrates were 14.7%, 30.3%, and 55.0%, respectively. **Table 1** shows the 5-d menu cycle of fresh fruits and stir-fried vegetables.

Food analysis

Food record-assisted 3-d dietary records were prepared. The software of the Nutrition Data System, developed by the Institute of Biomedical Sciences, Academia Sinica, Taiwan, Republic of China (ROC) was used. Details of this dietary assessment method are published elsewhere.[18,19]

Biochemical analyses

At wk 0, 1, 4, and 8, blood samples were collected from fasting subjects. Tubes were centrifuged (1200 x *g*, 10 min, 4 ^{0}C). Samples were stored at -70 ^{0}C until were analyzed for carotenoids, retinol, α-tocopherol, and lipid profiles. Carotenoid profiles and α-tocopherol in plasma were quantified by HPLC using a modified version of a method described previously.[20] After precipitation of the protein by absolute ethanol, carotenoids and α-tocopherol were extracted from the plasma by n-hexane and separated by HPLC. The HPLC was performed using a Hitachi L-2000 pump equipped with a Hitachi AS-2000 autosampler and a Hitachi L-7455 diode array detector. A C18 reverse-phase column (MS II, 4.6 x 250 mm, 5 μm; Cosmoscil, Nacalai Tesque Japan) was used. The flow rate was set a 1.5 mL/min, and wavelength of the detector was set at 450 nm for the detection of β-carotene, lutein/zeaxanthin, and β-cryptoxanthin, 470 nm for lycopene, and 295 nm for α- tocopherol. The mobile phase was methanol/toluene (3:1, v/v). Plasma retinol was determined by HPLC using a method described previously.[20] A C18 reverse-phase column (ACE® 5 C_{18}, 4.6 x 250 mm, 5 μm) was used. The flow rate was set a 1 mL/min, and the wavelength of the detector was set at 325 nm for the detection of retinal. The CV (coefficient of variation) were as follows: β-carotene, 4.4% and 4.3%, lutein/zeaxanthin, 5.3% and 4.7%, β-cryptoxanthin, 1.9% and 2.8%, lycopene, 5.7% and 6.3%, α-tocopherol, 2.4% and 2.7%, and retinol, 1.1% and 1.7%.

Chemical analyses of diet

The test meals were analyzed for carotenoid profiles by HPLC; samples were homogenized with a blender and a homogenizer. Homogenate (5 mL) was supplemented with a saponified solution consisting of 3 mL of absolute ethanol, 40 mg of $_L$-ascorbic acid and 7 mL of saturated KOH. The mixture was saponified at 70 ^{0}C for 2 h and extracted three times with 10 mL of n-hexane. The extract was washed twice with 10 mL of distilled water, and the solvent was evaporated under vacuum. The residue was redissolved in 1 mL of a mixture of methanol, and subjected to HPLC. The instruments and conditions of the HPLC for the analysis of carotenoids in food had been described for the analysis of plasma carotenoids.

Table 1. Five-day menu cycle of fruits and vegetables during dietary invention period

Meal	Day 1		Day 2		Day 3		Day 4		Day 5	
	Contents	Weight (g)	Contents	Weight (g)	Contents	Weight (g)	Contents	Weight (g)	Contents	Weight (g)
Lunch	Green pepper	20	Tomato	40	Carrot	20	Small cucumber	30	Green pepper	15
	Carrot	20	Pe-tsai	70	Onion	20	Carrot	20	Carrot	15
	Pineapple	10	Radish	20	Field mustard	80	Amaranth	100	Pineapple	10
	Hyacinth bean	20	Carrot	20	Bamboo	30	Guava	180	Hyacinth bean	50
	Cabbage	70	Orange	170	Orange	170			Chinese mustard	80
	Kelp	20							Kelp	20
	Grape	125							Grape	125
Dinner	Green pepper	20	Celery	20	Basil	10	Vegetable sponge	50	Tomato	50
	Carrot	20	Carrot	20	Cucumber	50	Bamboo	30	Jew's ear	10
	Mustard leaves	70	Jew's ear	20	Mustard leaves	70	Mustard leaves	70	Pe-tsai	70
	Eggplant	40	Cabbage	70	Mustard stem	20	Watermelon	300	Radish	20
	Orange	170	Radish	20	Pineapple	125			Grape	125
			Orange	170						

The cooking method of the vegetables was stir-frying.; The mixed test meals provided two servings of fruits and three servings of stir-fried vegetables each day (one serving equals 100 g of vegetables); The fruit was fresh.

Table 2. Characteristics of subjects

	Males (*n*=14)			Females (*n*=20)		
	0 wk	1 wk	4 wk	0 wk	1 wk	4 wk
Age (y)		24.4 ± 2.2			23.7 ± 1.1	
Height (cm)		170 ± 6			160 ± 5	
Weight (kg)	68.0 ± 12.1	67.5 ± 11.9	67.4 ± 12.1	55.2 ± 11.8	54.9 ± 11.7	54.9 ± 11.6
BMI (kg/m^2)	23.6 ± 3.8	23.4 ± 3.7	23.3 ± 3.8	21.6 ± 4.8	21.5 ± 4.6	21.4 ± 4.6

Values are the means ± SD; BMI, body mass index.

Table 3. Average daily intake of energy, protein, fat, and carbohydrates using 3-day food records in subjects during a 4-wk dietary intervention period

	Males (*n*=14)			Females (*n*=20)		
	0 wk	1 wk	4 wk	0 wk	1 wk	4 wk
Energy (kcal)	1981 ± 605	2211 ± 516	2012 ± 426	1728 ± 446	1845 ± 535	1823 ± 348
Protein (g)	69.3 ± 26.8 ^{b}	83.0 ± 20.6 ^{a}	83.7 ± 21.5 ^{a}	59.2 ± 15.5 ^{b}	70.7 ± 18.1 ^{a}	75.8 ± 18.9 ^{a}
Protein (en%)	13.4 ± 3.8 ^{b}	15.0 ± 1.9 ^{b}	16.7 ± 3.1 ^{a}	14.3 ± 4.1 ^{b}	15.6 ± 3.1 ^{a}	16.8 ± 3.8 ^{a}
Fat (g)	77.6 ± 29.6	72.9 ± 23.0	66.6 ± 23.8	69.7 ± 25.2	62.7± 20.7	60.6 ± 17.3
Fat (en%)	35.1 ± 7.5 ^{a}	29.9 ± 7.6 ^{b}	29.4 ± 6.6 ^{b}	36.4 ± 9.0 ^{a}	31.0 ± 8.4 ^{b}	30.0 ± 7.1 ^{b}
Carbohydrate (g)	253 ± 96 ^{b}	301 ± 78 ^{a}	271 ± 60 ^{b}	218 ± 75 ^{b}	252 ± 96 ^{a}	246 ± 65 ^{a}
Carbohydrate (en%)	51.0 ± 9.5	54.5 ± 8.1	54.2 ± 7.2	49.9 ± 10.1 ^{b}	54.0 ± 9.9 ^{a}	53.6 ± 8.6 ^{a}
Crude fiber (g)	2.9 ± 1.9 ^{b}	5.1 ± 2. 4 ^{a}	4.1 ± 2.4 ^{a}	2.6 ± 1.6 ^{c}	5.1 ± 2.2 ^{a}	3.9 ± 2.4 ^{b}

Values are the mean ± SD; Values in the same row with different superscripts significantly differ in the same genders; $p < 0.05$; en%, percent of energy.

Statistical analysis

Results are expressed as the mean ± SD, and the significant difference was determined by Student's *t*-test or one-way ANOVA followed by Fisher's least significant difference test by using the SAS statistical software package (SAS 6.12, USA).

RESULTS

The characteristics of subjects did not differ between the baseline and after 4th weeks of intervention (**Table 2**). However, the dietary fiber content of the meals significantly increased from 46%-116% during the 4 weeks of intervention **(Table 3)**. Before the study, male and female subjects ingested 189 and 212 g (≈1.9 and 2.1 servings) of fruits and vegetables, respectively. During the dietary invention periods, male and female subjects ingested 445 and 478 g (≈4.5and 4.7 servings) of fruits and vegetables, respectively (data not shown).

Table 4 shows that serum total cholesterol, HDL-C, and LDL-C concentrations had significantly decreased at wk 1 and 4 in female subjects. In male subjects, serum total cholesterol and LDL-C tend to decrease only serum HDL-C concentration significantly decreased at week 4. Carotenoid contents of the test meal were as follows: β-carotene, 14.2 ± 6.6, lycopene, 1.4 ± 2.2, lutein/zeaxanthin, 1.5 ± 0.7, and β-cryptoxanthin, 0.06 ± 0.03 mg/day (**Table 5**). After subjects had ingested the test meals for the 4-wk period, plasma carotenoid levels in male and female subjects had increased by the following amounts: β-carotene, 19%-32%, lycopene, 15%-47%, and β-cryptoxanthin, 59%-88% at wk 1 and 4 ($p < 0.05$). However, plasma retinol and α-tocopherol concentrations were within the normal range at baseline for both genders. In male subjects, plasma lutein/zeaxanthin concentrations increased slightly, but there was no statistical difference at week 1, and they had increased significantly by 48% at wk 4. At wk 1 and 4, plasma lutein/zeaxanthin concentrations had significantly increased by 15%-21% in female subjects (**Tables 6**). After the subsequent 4-wk washout periods, concentrations of carotenoids in plasma declined almost to initial values (except for lutein/zeaxanthin and β-cryptoxanthin).

DISCUSSION

Fruits and vegetables are rich sources of a wide range of potentially beneficial components including dietary fiber, vitamin, minerals, and phytochemicals including carotenoids and phenolic compounds. The present study reveals that an increased intake of two and a half serving of fruits and vegetables to a total of 4.5-4.7 servings of fruits and stir-fried vegetables daily for 4 weeks resulted in increased plasma carotenoid concentrations. The increase was from 19%-32% for β-carotene, 15%-47% of lycopene, 59%-88% of β-cryptoxanthin and 15%-48% of lutein/zeaxanthin. Most of the plasma carotenoids had significantly increased by week 1 after intake of the mixed test meals. Thus, plasma carotenoids can be used as a marker of recent fruit and vegetable intake.[21,22] Likewise the detection of carotenoids in plasma can be used as a marker of short term changes in dietary carotenoid intake. This study appears to be consistent with the investigations which showed that consumption of 500 g of fruits and vegetables daily for 4 wk in comparison to 100 g of fruits and vegetables (increasing intake by four servings of fruits and vegetables) results in significantly higher plasma carotenoid concentrations, including β-carotene

Table 4. Blood lipid profiles, a-tocopherol, and retinol concentrations of subjects during a 4-wk dietary intervention period.

	Males (*n*=14)			Females (*n*=20)		
	0 wk	1 wk	4 wk	0 wk	1 wk	4 wk
TC (mmol/L)	4.6 ± 0.8	4.4 ± 0.8	4.4 ± 0.7	4.4 ± 0.7	4.2 ± 0.7*	4.2 ± 0.6*
TG (mmol/L)	0.7 ± 0.2	0.8 ± 0.3	0.8 ± 0.3	0.7 ± 0.2	0.7 ± 0.2	0.7 ± 0.3
HDL-C (mmol/L)	1.4 ± 0.2	1.5 ± 0.5	1.3 ± 0.2*	1.6 ± 0.3	1.5 ± 0.3*	1.4 ± 0.2*
LDL-C (mmol/L)	2.8 ± 0.6	2.7 ± 0.7	2.7 ± 0.6	2.8 ± 0.8	2.6 ± 0.8*	2.5 ± 0.6*
α-TE (mmol/L)	6.5 ± 1.5	7.5 ± 1.5 *	8.5 ± 1.5*	8.0 ± 2.3	8.4 ± 1.9	10.0 ± 2.6*
Retinol (mmol/L)	2.4 ± 0.5	-	2.3 ± 0.2	2.1 ± 0.5	-	2.0 ± 0.4

Values are the mean ± SD.; Values significantly differ from baseline (0 wk) in the same genders; * $p< 0.05$.; TC, total cholesterol; TG, triglyceride; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol, α-TE, α-tocopherol.

Table 5. Carotenoid contents of fruits and stir-fried vegetables in the mixed test meals excluding breakfast

	Carotenoid contents	Range
β-Carotene (mg/day)	14.2 ± 6.6	7.51-25.3
Lycopene (mg/day)	1.4 ± 2.2	0.05-4.44
Lutein/zeaxanthin (mg/day)	1.5 ± 0.7	1.16-2.48
β-Cryptoxanthin (mg/day)	0.06 ± 0.03	0.03-0.12

Values are the mean ± SD, *n* = 6.

Table 6. Plasma carotenoid concentrations of subjects during a 4-wk dietary intervention period

	β-Carotene (μmol/L)		Lycopene (μmol/L)		Lutein/zeaxanthin (μmol/L)		β-Cryptoxanthin (μmol/L)	
	Males (*n*=14)	Females (*n*=20)	Males (*n*=14)	Females (*n*=20)	Males (*n*=14)	Females (*n*=20)	Males (*n*=14)	Females (*n*=20)
Before	0.32 ± 0.15	0.39 ± 0.20	0.25 ± 0.08	0.27 ± 0.17	0.28 ± 0.12	0.36 ± 0.13	0.08 ± 0.06	0.15 ± 0.12
After 1 wk intervention	0.38 ± 0.16*	0.52 ± 0.19*	0.29 ± 0.10*	0.32 ± 0.13*	0.30 ± 0.09	0.41 ± 0.13*	0.14 ± 0.06*	0.25 ± 0.12*
After 4 wk intervention	0.40 ± 0.13*	0.51 ± 0.23*	0.37 ± 0.11*	0.39 ± 0.13*	0.41 ± 0.08*	0.43 ± 0.15*	0.15 ± 0.07*	0.26 ± 0.13*
Change (%)	19.2-25.8	29.6-32.1	14.8-47	16.6-41.9	7.4-47.7	15.2-21.4	65.7-87.9	59.4-69.9
4 wk washout after	0.21 ± 0.18	0.36 ± 0.11	0.21 ± 0.07	0.25 ± 0.06	0.52 ± 0.22*	0.60 ± 0.16*	0.13 ± 0.06*	0.23 ± 0.05*

Values are the mean ± SD.; Values significantly differ from the baseline (0 wk) in the same genders; * $p < 0.05$

(45%), α-carotene (121%), lycopene (22%), β-cryptoxanthin (128%) and lutein (46%).[9] In the present study, increasing consumption of two and a half servings of fruits and stir-fried vegetables increased plasma carotenoids from 15%-88%. In particular, plasma β-cryptoxanthin concentrations increased higher percentage than the other carotenoids. Citrus fruits (e.g., oranges, and tangerines) are a major contributor of β-cryptoxanthin[23] and, therefore, may have contributed to the increased levels of plasma β-cryptoxanthin from 59%-88%. Apparently, this study showed higher concentrations of plasma lycopene compared to other reported data. The higher concentrations in our study may be attributed to the use of the stir-fry cooking method. Stir-frying may have increased the absorption of carotenoids by the subjects.[24]

After the subsequent 4-wk washout periods, concentrations of carotenoids in plasma declined almost to initial values (except for lutein/zeaxanthin and β-cryptoxanthin) in both genders. This may be due to subjects returning to their original dietary habits of low carotenoid diets. The present study indicated plasma carotenoid concentrations were associated with dietary habits, vitamin A status, cooking method, and dietary fat.

Dietary habits

Plasma carotenoid concentrations in the present study appear to be consistent with the National Health and Nutrition Examination Survey (NHANES III).[25] β-Carotene had similar distribution while lycopene, lutein and β-cryptoxanthin were lower. The discrepancies may be due to differences in dietary patterns between the two studies. As generally known, Asian diets are deficient in tomato-based products compared to European diets. This may be one of the reasons why plasma lycopene levels are higher in European population compared to Asians.[26]

Vitamin A status

The physiological condition and nutritional status of the host may affect carotenoid absorption in humans. The normal range of plasma retinol concentrations in humans are 1.5-3.0 μmol/L.[27] Some studies have indicated that maintaining the vitamin A status can minimize the bioconversion of β-carotene to vitamin A.[15] In this study, subjects did not have vitamin A deficiency, so it did not affect carotenoid absorption.

Cooking method

Some studies have indicated the β-carotene bioavailability from raw vegetables is less than that from cooked or processed vegetables.[17,28] Cooking, homogenization, and processing can improve the bioavailability of carotenoids from foods,[28,29] possibly due to the increased extractability of carotenoids from the food matrix, because disruption of the food matrix with the concomitant release of carotenoid is the first step in carotenoid absorption. In a study, daily provision of 500 g of fruits and vegetables for 4 wk resulted in plasma carotenoids showing no significant changes compared with the baseline.[9] Consequently, in the present study, an increased intake of fruits and stir-fried vegetables resulted in increased plasma carotenoids concentrations. The difference in results may be due to the use of different cooking methods. Our results appear to be in agreement with the previously study[24] who indicated that β-carotene bioavailability from stir- or deep-fried vegetables (e.g. carrots and water convolvulus leaves) was higher than the reported data.[17,30,31] The discrepancies in data may be due to the types of meals tested, duration of the study and the types of carotenoids analyzed.

Amount of dietary fat

In recent studies, a minimum amount of ≈3-5 g of dietary fat may be needed in a meal to ensure intestinal carotenoid uptake.[32,33] The present study used 60-72 g of dietary fat (≈ 28%-34% of energy). The large amount of fat used may have contributed to higher absorption rates.

Various studies have shown that plasma β-carotene in the range of 0.34 to 0.53 μmol/L is associated with relatively low risks of total death, cardiovascular disease, and cancer.[8] In the present study, plasma β-carotene concentrations were 0.38-0.52 μmol/L, which is within the range for low risks of cancer and cardiovascular disease. Epidemiological studies show some associations between dietary intake of fruits and vegetables and reduced risk of cancer and chronic disease. Diets which provide 400-600 g of fruits and vegetables each day are associated with a reduced risk of lung cancer and other aerodigestive epithelial cancers.[34] In this study, male and female subjects on average ingested 473 and 458 g of fruits and vegetables, respectively. Increasing fruit and stir-fried vegetable intake significantly increased plasma carotenoid concentrations which may, consequently, reduce the risk of chronic diseases.[35,36]

Increases from two and a half servings to ≈five servings of fruits and stir-fried vegetables in a Taiwanese mixed diet for 4 wk significantly increased plasma carotenoid concentrations from 15% to 88% in young adults which is likely to have meaningful biological relevance.

AUTHOR DISCLOSURES

Yu-Ju Lin, Yi-Wen Chien, Shwu-Huey Yang and Hsing-Hsien Cheng, no conflicts of interest.

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Original Article

Fruits and stir-fried vegetables increase plasma carotenoids in young adults

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攝取水果與炒青菜可增加年輕人血漿類胡蘿蔔素的濃度

本次研究以飲食介入方式探討年輕成年受試者在增加水果及台灣地區日常飲食炒青菜攝取量，對其血漿類胡蘿蔔素濃度的影響。招募 34 位健康、無吸煙習慣及每天平均攝取低於 2.5 份蔬菜及水果的受試者加入本研究。受試者接受四週的飲食介入試驗，星期一～星期五提供受試者午餐及晚餐的試驗飲食。餐食包括 3 份炒青菜與 2 份新鮮水果。受試者在攝取試驗飲食第一週及第四週後，血漿 β-胡蘿蔔素、番茄紅素及 β-玉米黃素分別顯著性增加 19-32%、15-47%、59-88%。受試者在停止攝取試驗飲食四週後，其血漿中 β-胡蘿蔔素及番茄紅素的濃度皆顯著降低。持續攝取富含類胡蘿蔔素的飲食可維持較高的血漿類胡蘿蔔素的濃度，有助於預防慢性病的發生。

關鍵字：水果、炒青菜、β-胡蘿蔔素、β-玉米黃素、番茄紅素、年輕人。