



AMERICA'S PHYTONUTRIENT REPORT

QUANTIFYING THE GAP

Executive Summary

When the current Dietary Guidelines for Americans were released in 2005, the federal recommendations for fruits and vegetables increased from 5-9 servings to 5-13 servings per day for adults. Unfortunately, despite the recommendations and known health benefits of fruits and vegetables, Americans are not consuming these recommended intake levels – there is a “phytonutrient gap”.

Because phytonutrients are not considered “essential” to human health, there are no Dietary Reference Intakes (DRIs), as there are for the macro and micronutrients. This report is not designed to establish DRIs for phytonutrients. Rather, in order to determine a desirable intake level for health, or “prudent intake” (PI), the median intake of phytonutrients by the subpopulation of adults who meet recommended daily intakes of fruits and vegetables was identified using NHANES and USDA datasets. The percent of Americans who failed to meet the PI was then determined.

While scientists continue to identify unique, plant-based nutrients, this report focused on 14 select phytonutrients including carotenoids (alpha-carotene, beta-carotene, beta-cryptoxanthin, lutein/zeaxanthin), flavonoids (anthocyanidins, epigallocatechin 3-gallate, hesperitin, quercetin), phenolics (ellagic acid, resveratrol), isothiocyanates, isoflavones and allicin. The 14 phytonutrients of interest were grouped into color categories based on their primary pigments. These groupings allowed for the quantification of the percent of Americans with a “phytonutrient gap” to be ascertained by color.

Based on the analyses of this report, Americans are falling short in virtually every color category of phytonutrients:

- ▶ 69% fall short in green
- ▶ 78% fall short in red
- ▶ 86% fall short in white
- ▶ 88% fall short in purple/blue
- ▶ 79% fall short in yellow/orange

Therefore, on average, 8 out of 10 Americans have a phytonutrient gap. Ideally, Americans should seek approximately 10 servings of fruits and vegetables daily, which could be interpreted as 2 servings from each color category presented. While the exact balance of servings per color could be debated among health and nutrition professionals, the goal of having Americans consume 2 servings from each color category for a total of 10 servings is easy and straightforward for consumers to follow. A simple message of whole foods first is important, along with the message to choose richer and more vibrantly colored foods whenever possible. Beyond this, dietary supplementation may be an option for individuals looking to reduce their phytonutrient gap.

Background

Eating more fruits and vegetables has been associated with a decreased risk for chronic diseases including cardiovascular disease, cancer and diabetes.¹⁻⁸ Fruits and vegetables are important sources of key nutrients, such as potassium, dietary fiber, folic acid, vitamins A, C and E. Additionally, they contain naturally occurring compounds referred to as phytochemicals or phytonutrients, which may have health benefits beyond basic nutrition. Therefore, in the simplest of terms, Americans could become healthier by choosing to eat more fruits and vegetables daily.

When the current Dietary Guidelines for Americans were released in 2005, the federal recommendations for fruits and vegetables increased from 5-9 servings to 5-13 servings per day for adults, which is about 2.5 to 6.5 cups a day depending on gender, age and activity level.⁹ The Dietary Guidelines for Americans 2005 also state:

- ▶ Consume a variety of nutrient-dense foods;
- ▶ Consume a sufficient amount of fruits and vegetables while staying within energy needs;
- ▶ Choose a variety of fruits and vegetables each day; and
- ▶ Select from all five vegetable subgroups (dark green, orange, legumes, starchy vegetables and other vegetables) several times a week.

Regardless of whether a dietary pattern is evaluated against these guidelines, or MyPyramid fruit and vegetable recommendations which vary slightly, Americans fall woefully short on meeting fruit and vegetable intakes. Recent research indicates that fewer than 1 in 10 Americans meet their calorie-specific MyPyramid fruit or vegetable recommendations.¹⁰ Consumer research indicates the primary factors preventing them from eating sufficient amounts of fruits and vegetables are fear of spoilage, price and lack of availability and convenience.¹¹

Given this shortfall in fruit and vegetable consumption, this report asks one main question – what is the gap in phytonutrient consumption among Americans?

What are Phytonutrients?

The term “*phyto*” originates from the Greek word meaning plant. Phytonutrients are natural components of plants thought to offer benefits to health. Fruits, vegetables, grains, legumes, nuts and teas are rich sources of phytonutrients. Unlike the basic nutrients (protein, fat, carbohydrates, vitamins, minerals), phytonutrients are not “essential” for life, so some scientists prefer the term “phytochemical” rather than “phytonutrient”. However, for consumer messaging, the term “phytonutrient” conveys a stronger health message given people prefer to eat “nutrients” rather than “chemicals”. For the purposes of encouraging consumers to eat more fruits and vegetables, it is advised to use the nutrient terminology.

While phytonutrients have been part of the chemical composition of fruits and vegetables for as long as they have been grown, it is only in recent years that specific phytonutrients have been isolated, identified, and studied for their many beneficial qualities. Scientists are continuing to identify new phytonutrients in fruits and vegetables – one orange is believed to contain over 170 phytonutrients! For the purposes of quantifying the phytonutrient gap, this report focuses on 14 phytonutrients of interest including carotenoids (alpha-carotene, beta-carotene, beta-cryptoxanthin, lutein/zeaxanthin), flavonoids (anthocyanidins, epigallocatechin 3-gallate or “EGCG”, hesperitin, quercetin), phenolics (ellagic acid, resveratrol), isothiocyanates, isoflavones and allicin.

The descriptive science names may be confusing to the average consumer, and yet, it is important for consumers to understand a “food first” message within an “eat by color” paradigm which encompasses the phytonutrients. Quite simply, consumers should ideally eat the richest colors from each color grouping, and consume 2 servings a day from each for a total of 10 servings of fruits and vegetables per day. In order to align with an “eat by color” paradigm, this report will quantify the phytonutrient gap *by color*. The 14 phytonutrients are grouped as follows (Table 1):

Table 1: Phytonutrients of Interest Grouped By Color

COLOR CATEGORY	PHYTONUTRIENTS INCLUDED	
GREEN	EGCG Lutein/zeaxanthin	Isothiocyanate Isoflavones
RED	Lycopene	Ellagic Acid
WHITE	Allicin	Quercetin
PURPLE/BLUE	Anthocyanidins	Resveratrol
YELLOW/ORANGE	Alpha-carotene Hesperitin	Beta-carotene Beta-cryptoxanthin

Methodology & Data Sourcing

Nutrient intakes were based on food consumption records collected as part of the National Health and Nutrition Examination Surveys (NHANES) conducted in 2003-2004 and 2005-2006.^{12,13}

The NHANES datasets provide nationally representative nutrition and health data and prevalence estimates for nutrition and health status measures in the United States. A total of 16,783 individuals in the survey period 2003-2006 provided 2 complete days of dietary recalls. The analyses in this report utilize 2-day average intakes, not usual intakes.

For each food reported in NHANES, USDA databases provide information on the amount of energy and approximately 60 nutrients or food constituents per 100 g of each food. USDA's Food and Nutrient Database for Dietary Studies 3.0 (FNDDS 3), which is based on nutrient composition data in the USDA National Nutrient Database for Standard Reference, Release 20 (SR 20), represents the most recent nutrient concentration data.¹⁴ This database was used to identify the amount of each phytonutrient found in foods including alpha-carotene, beta-carotene, beta-cryptoxanthin, and lutein/zeaxanthin. USDA's SR 21 database, which includes values from recent analyses of concentrated lycopene sources (tomato-based sauces), was used to identify the amount of lycopene in each reported food.¹⁵ The most recent USDA flavonoid database was used to identify concentrations of anthocyanidins, epigallocatechin 3-gallate, hesperitin, and quercetin in each food reported by NHANES respondents in 2003-2006.¹⁶ The USDA isoflavone database was used to identify concentrations of total isoflavones in each food as reported.¹⁷

Fruit and Vegetable Intake Falling Short

MyPyramid dietary guidance, which supports the 2005 Dietary Guidelines for Americans, includes recommendations for amounts of fruits and vegetables that should be consumed daily as part of a healthy diet.¹⁸ Women should consume 2.0-2.5 cups of vegetables and 1.5-2.0 cups of fruits, which means up to 4.5 cups or 9 servings of fruit and vegetables per day (see Table 2). Men should have between 2.5-3.0 cups of vegetables and 2.0 cups of fruits, which means up to 5.0 cups or 10 servings of fruits and vegetables per day. Each cup equivalent of fruits is generally equivalent to 1 cup of fresh fruit, 8 ounces of 100% fruit juice, or 0.5 cups of dried fruit. A cup equivalent of vegetables is generally equivalent to 1 cup of raw or cooked vegetables, 8 ounces of vegetable juice, or two cups of raw leafy greens.

Based on these analyses, 3 to 12% of Americans are able to meet their MyPyramid target for combined fruit *and* vegetable intake recommendations – the so-called “meeters” (see Table 3). Notably, females over the age of 65 years tend to fare best (12% meet recommendations), while adults under 44 years were least likely to meet their fruit and vegetable recommended intakes (3% meet recommendations). When considering those who meet just fruit recommendations or just vegetable recommendations, the percents are higher. For example, 36% of females over the age of 65 years meet their fruit intake, while 26% of men ages 45-64 years meet their vegetable intake recommendations.

Table 2: MyPyramid Fruit and Vegetable Recommended Intakes

POPULATION	DAILY FRUIT INTAKE	DAILY VEGETABLE INTAKE
WOMEN		
19-30 YEARS OLD	2 CUPS	2 ½ CUPS
31-50 YEARS OLD	1 ½ CUPS	2 ½ CUPS
51+ YEARS OLD	1 ½ CUPS	2 CUPS
MEN		
19-30 YEARS OLD	2 CUPS	3 CUPS
31-50 YEARS OLD	2 CUPS	3 CUPS
51+ YEARS OLD	2 CUPS	2 ½ CUPS

Table 3: Percent Meeters and Non-Meeters

POPULATION	MEET FRUIT RECOMMENDATIONS		MEET VEGETABLE RECOMMENDATIONS		MEET FRUIT AND VEGETABLE RECOMMENDATIONS		DO NOT MEET FRUIT AND VEGETABLE RECOMMENDATIONS	
	N	PERCENT	N	PERCENT	N	PERCENT	N	PERCENT
M 19 – 44Y	309	15	293	18	63	3	1780	97
F 19 – 44Y	266	15	255	17	59	3	1614	97
M 45 – 64Y	209	20	257	26	64	6	1085	94
F 45 – 64Y	346	27	326	28	122	9	1130	91
M 65+Y	241	23	222	23	67	7	1025	93
F 65+Y	369	36	278	27	126	12	937	88
ALL ADULTS	1740	21	1631	22	501	6	7571	94

Y=years, M= male, F= female, N=sample size

A Dietary Reference Intake for Phytonutrients?

Because these plant-based compounds found in fruits and vegetables – the phytonutrients – are not considered “essential” to human health, there are no Dietary Reference Intakes (DRIs) as there are for the macronutrients and micronutrients. The lack of a DRI is not a result of the lack of importance of phytonutrients in the diet, but rather the establishment of reference intakes would be an arduous process not yet given a high priority.

To be clear, this report is not designed to establish DRIs for phytonutrients. Rather, in order to determine a “prudent intake” (PI) for each of the phytonutrients, or desirable intake level for health, the median intake of phytonutrients by the subpopulation of adults who meet recommended daily intakes of fruits and vegetables was identified. Where there was limited intake data to determine a PI, existing published literature on intake levels was used to identify consumed levels associated with health.

Specifically, the 50th percentile of those meeting MyPyramid recommendations was identified as the median, and thus the PI (see Table 4). For example, the median intake for EGCG was 3.2 mg/day, so this value became the “PI” for EGCG. The units of measure differed for the 14 PIs because the units were anchored to the existing intake data and scientific literature on each phytonutrient in terms of intake levels. These PIs were then used as reference intakes to determine the percentage of the population above and below the median intake level – the “meeters” (at or above the PI) versus the “non-meeters” (below the PI).

Table 4: Establishment of Prudent Intakes (PI) for Select Phytonutrients by Color

PHYTONUTRIENT BY COLOR	MEETING MYPYRAMID RECOMMENDATIONS				NOT MEETING MYPYRAMID RECOMMENDATIONS			
	PERCENTILE				PERCENTILE			
	MEAN	25 TH	50 TH	75 TH	MEAN	25 TH	50 TH	75 TH
GREEN								
EGCG (mg/d)	22.3	0.6	3.2	29.3	23.7	0.0	0.4	21.7
Isoflavones (mg/d)	4.7	0.2	0.7	5.1	3.2	0.1	0.3	1.4
Isothiocyanate (mg/d)	1.71	0	0.20	1.00	1.65	0	0	0.73
Lutein/zeaxanthin (mcg/d)	3443	1290	2055	3899	1374	408	744	1372
RED								
Ellagic Acid (mg/d)	7.8	4.0	6.7	10.6	2.5	0.0	1.0	3.6
Lycopene (mcg/d)	9656	2189	6332	14078	5255	627	2837	7398
WHITE								
Allicin (mg/d)*	0.85	0	0	0.6	0.42	0	0	0.01
Quercetin (mg/d)	28.8	19.9	26.6	34.9	15.0	7.5	12.5	19.5
PURPLE/BLUE								
Anthocyanidins (mg/d)	13.5	7.3	11.2	15.8	4.7	0.8	2.8	6.2
Resveratrol (mg/d)	4.13	0.20	0.95	4.65	2.26	0.00	0.19	1.00
Resveratrol (mg/d) – excluding wine	1.82	0.08	0.49	2.74	0.67	0.00	0.11	0.56
YELLOW/ORANGE								
Alpha-carotene (mcg/d)	966	159	518	1393	353	25	77	395
Beta-carotene (mcg/d)	5240	2256	3787	6890	1909	432	1003	2409
Beta-cryptoxanthin (mcg/d)	302	101	223	409	122	12	42	158
Hesperitin (mg/d)	3.03	0.15	0.90	3.83	1.37	0	0.07	0.95

*Note: the median intake of allicin by “meeters” was zero, therefore the PI for allicin was defined by the value of the mean intake.

Quantifying the Gap By Color

Beginning with the green group, the following sections identify the phytonutrients and their health benefits, as well as the percentage of Americans who meet the PI for a given phytonutrient. Note, in each case, this percent includes all individuals who comprised the survey set, regardless of whether they were classified as a “meeter” or “non-meeter”. This means that the phytonutrient gaps present reflect a representative sample of adult dietary patterns in the United States, not just people who consume higher levels of fruits and vegetables.

THE GREEN GROUP

EGCG

Epigallocatechin-3-gallate, or EGCG, is a polyphenolic compound present in green tea, and tea is second only to water as a major component of fluid intake worldwide.¹⁹ EGCG may offer neuroprotective effects for people with Alzheimer's disease,²⁰ and may help stop the proliferation of cancerous cells in the lungs.²¹ Further, a recent meta-analysis on breast cancer showed the combined results of green tea consumption from four studies showed a reduced risk of breast cancer for the highest versus lowest intake groups.²²

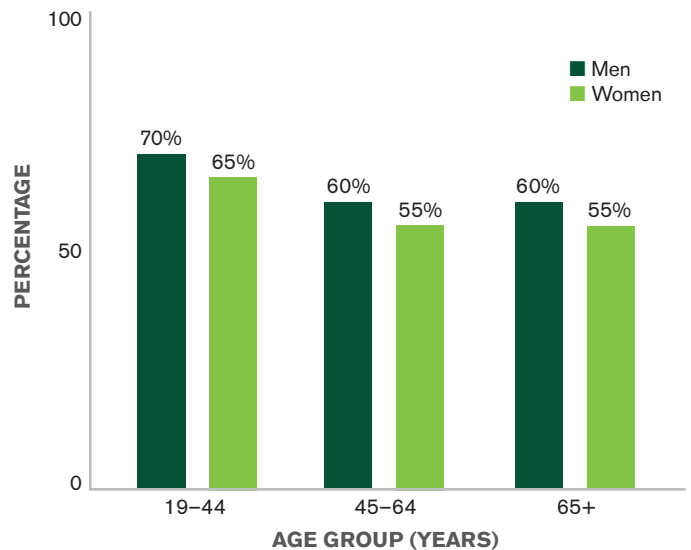
The PI for EGCG was found to be 3.2 mg/day. Among all adults 19 years and older, 35% meet this PI, which means 65% fall short. Graph 1 shows the percent of Americans, by age group, who have a gap in their EGCG consumption.

Isothiocyanates

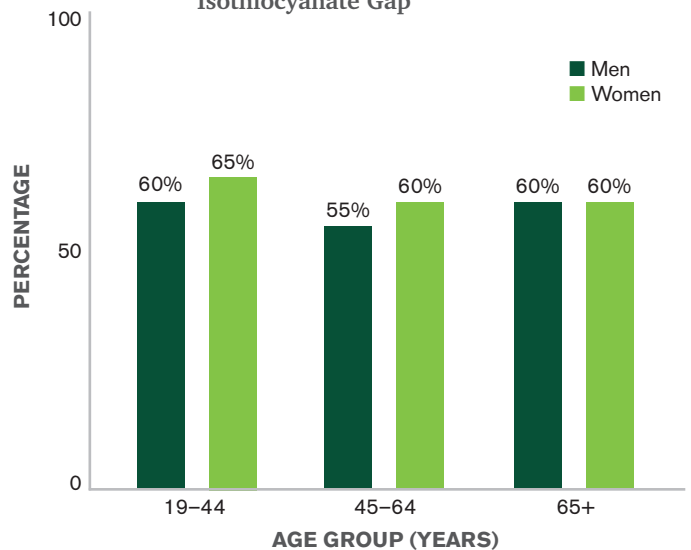
Isothiocyanates are derived from the breakdown of glucosinolates – sulfur-containing compounds found in cruciferous vegetables such as broccoli, cabbage and kale. Research on isothiocyanates has shown them to be protective of DNA, to inhibit cell proliferation, and to stop the progression of some tumors.²³ Several epidemiological studies have reported an inverse association between consumption of dietary isothiocyanates and cancer risk in several organs.²⁴⁻²⁷ Among genetically susceptible individuals, low intakes of cruciferous vegetables may be associated with higher kidney cancer risks in particular.²⁸

The PI for isothiocyanate was found to be 0.2 mg/day. Among adults 19 years and older, 36% meet this PI, which means 64% fall short. Graph 2 shows the percent of Americans, by age group, who have a gap in their isothiocyanate consumption.

Graph 1: Percentage of Americans with EGCG Gap



Graph 2: Percentage of Americans with Isothiocyanate Gap

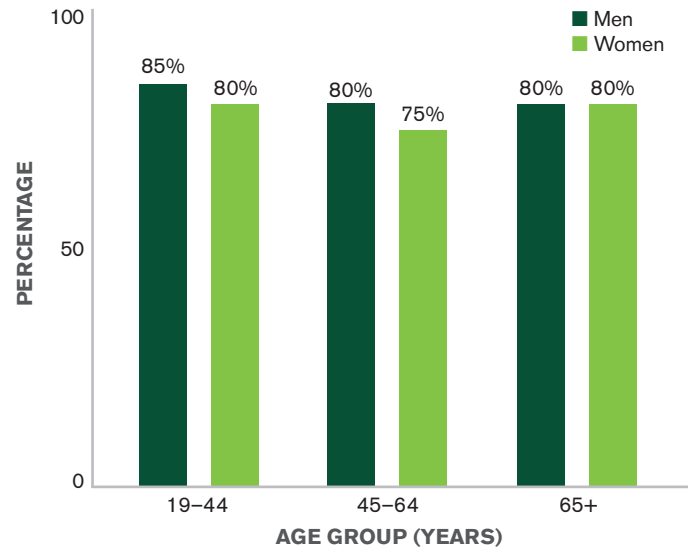


Lutein/Zeaxanthin

Lutein is found in green, leafy vegetables, and offers a high level of antioxidant activity. High levels of lutein, and zeaxanthin (a closely related carotenoid pigment derived from lutein), are thought to reduce the risk of age-related macular degeneration, which is the leading cause of blindness in the elderly.²⁹ Lutein/zeaxanthin pigments function as blue-light filters, and offer the potential to preserve vision. In one study of older individuals, those with the highest dietary intake of lutein/zeaxanthin had the lowest risk of AMD,³⁰ and more recent research supports the reversal of eye dysfunction with daily supplementation over the course of one year.³¹

The PI for lutein/zeaxanthin was found to be 2055 mcg/day. Among adults 19 years and older, 17% meet this PI, which means 83% fall short. Graph 3 shows the percent of Americans, by age group, who have a gap in their lutein/zeaxanthin consumption.

Graph 3: Percentage of Americans with Lutein/Zeaxanthin Gap

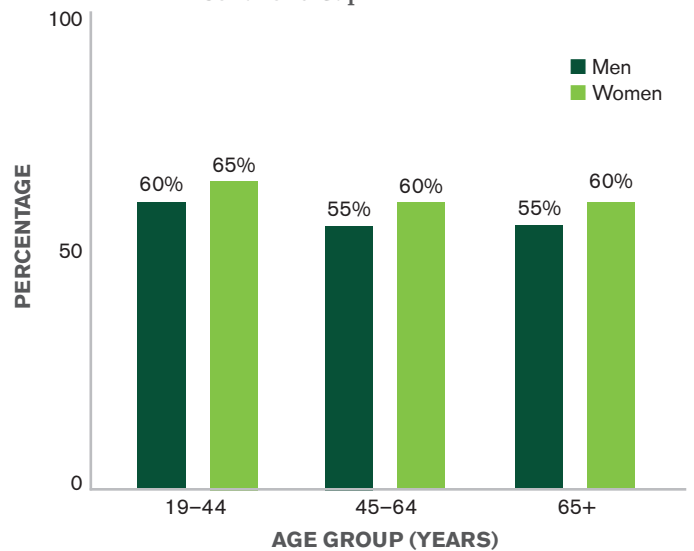


Isoflavone

Isoflavones are a class of phytoestrogens – plant-derived compounds with estrogenic activity. Soybeans and soy products are the richest source of isoflavones in the human diet. The consumption of soy products has been investigated for many possible health benefits. One of the major isoflavones, daidzein, has been shown to offer natural antioxidant properties,³² and there is growing evidence that isoflavones may play a role in decreasing the risk of lung cancer.³³

The PI for isoflavones was found to be 0.7 mg/day. Among adults 19 years and older, 37% meet this PI, which means 63% fall short. Graph 4 shows the percent of Americans, by age group, who have a gap in their isoflavone consumption.

Graph 4: Percentage of Americans with Isoflavone Gap



The Green Group Summary

The average percent of Americans who fail to meet their EGCG PI is 65% across all age groups. The average percent of Americans who fail to meet their isothiocyanate PI is 64% across all age groups. The average percent of Americans who fail to meet their lutein/zeaxanthin PI is 83% across all age groups. The average percent of Americans who fail to meet their isoflavone PI is 63% across all age groups. Therefore, on average, approximately 68.8% $[(65+64+83+63)/4]$ of Americans fail to meet their phytonutrient intake within the green phytonutrient color grouping.



THE RED GROUP

Lycopene

Lycopene, a naturally occurring plant compound extracted from tomatoes, is a carotenoid that exhibits potent antioxidant activity. Epidemiological studies have indicated that there is a correlation between increased tomato intake and reduced risk of prostate cancer³⁴ and men with high serum lycopene levels appear to be at a lower risk of prostate cancer than men with low levels.³⁵

The PI for lycopene was found to be 6332 mcg/day. Among adults 19 years and older, 31% meet this PI, which means 69% fall short. Graph 5 shows the percent of Americans, by age group, who have a gap in their lycopene consumption.

Ellagic Acid

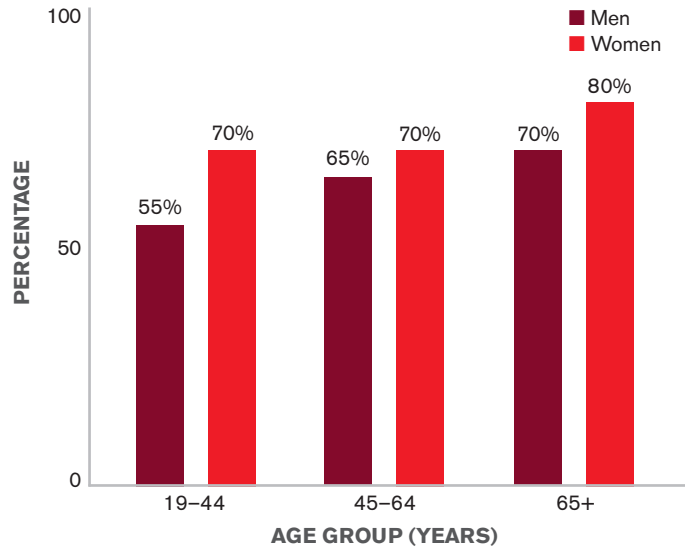
Ellagic acid is a substance found in various fruits, nuts and vegetables, including pomegranates, strawberries and walnuts. Research suggests that ellagic acid may help reduce DNA damage³⁶ and possibly help protect against breast cancer.³⁷ In one study of prostate cancer, patients receiving ellagic acid in combination with chemotherapy had lower rates of a chemotherapy-related side effect (reduced white blood cells) compared to patients receiving chemotherapy alone, although the ellagic acid did not slow tumor growth, or increase survival time.³⁸

The PI for ellagic acid was found to be 6.7 mg/day. Among adults 19 years and older, 13% meet this PI, which means 87% fall short. Graph 6 shows the percent of Americans, by age group, who have a gap in their ellagic acid consumption.

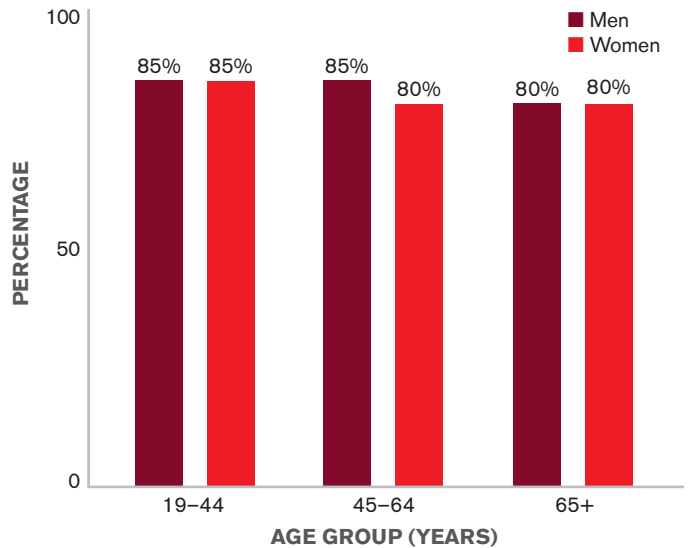
The Red Group Summary

The average percent of Americans who fail to meet their lycopene PI is 69% across all age groups. The average percent of Americans who fail to meet their ellagic acid PI is 87% across all age groups. Therefore, on average, approximately 78.0% $([69+87]/2)$ of Americans fail to meet their phytonutrient intake within the red phytonutrient color grouping.

Graph 5: Percentage of Americans with Lycopene Gap



Graph 6: Percentage of Americans with Ellagic Acid Gap



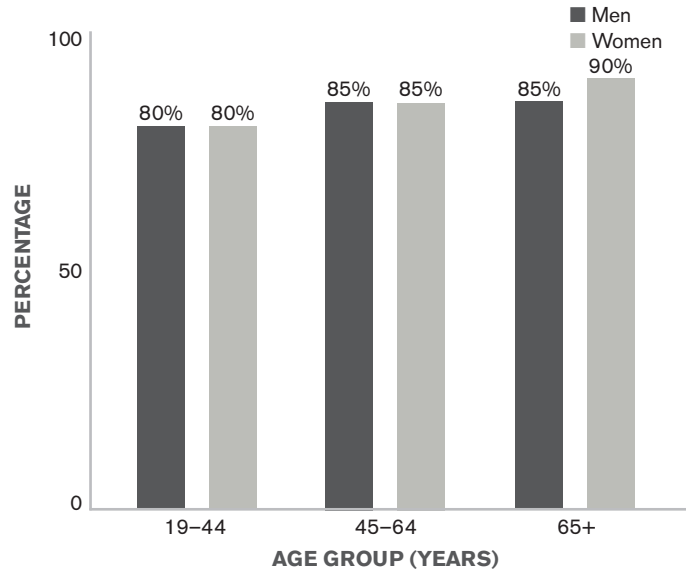
THE WHITE GROUP

Allicin

Allicin is a sulfur compound found in garlic, onions, shallots, leeks and other white-colored foods. Garlic has been shown to reduce total cholesterol³⁹ and to be protective against cardiovascular disease in part through anti-platelet activity.^{40,41} Garlic has also been shown to play a positive role in blood pressure among patients with identified hypertension.^{42,43}

The PI for allicin was found to be 0.85 mg/day. Among adults 19 years and older, 15% meet this PI, which means 85% fall short. Graph 7 shows the percent of Americans, by age group, who have a gap in their allicin consumption.

Graph 7: Percentage of Americans with Allicin Gap

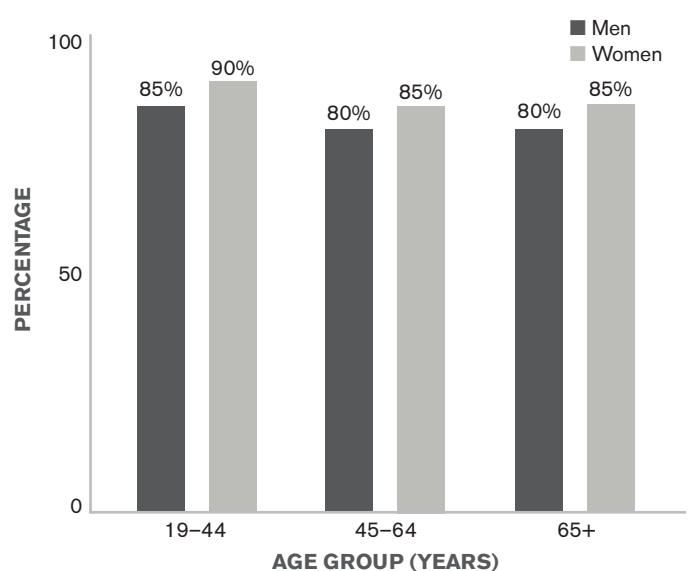


Quercetin

Commonly found in apples and onions, quercetin is a type of plant-derived flavonoid, known as a flavanol. Quercetin has been shown to be a powerful antioxidant, and to offer strong antimutagenic properties.^{44,45} Daily doses of quercetin (150 mg/day) have been effective in reducing blood pressure and “bad cholesterol” (plasma LDL cholesterol concentrations) in overweight individuals at high risk for heart disease.⁴⁶ Quercetin may also inhibit bone loss by regulating both systemic and local factors including hormones and cytokines.⁴⁷

The PI for quercetin was found to be 26.6 mg/day. Among adults 19 years and older, 14% meet this PI, which means 86% fall short. Graph 8 shows the percent of Americans, by age group, who have a gap in their quercetin consumption.

Graph 8: Percentage of Americans with Quercetin Gap



The White Group Summary

The average percent of Americans who fail to meet their allicin PI is 85% across all age groups. The average percent of Americans who fail to meet their quercetin PI is 86% across all age groups. Therefore, on average, approximately 85.5% $([85+86]/2)$ of Americans fail to meet their phytonutrient intake within the white phytonutrient color grouping.



THE PURPLE/BLUE GROUP

Anthocyanidins

Anthocyanidins, a subclass of flavonoids, are typically found in berries such as blueberry, elderberry or grapes. Research findings suggest blueberry or Concord grape juice supplementation, both offering high levels of anthocyanidins, can increase verbal memory performance in humans with mild cognitive impairment.⁴⁸ It is believed that anthocyanidins may exert their beneficial effects through signal transduction and neuronal communication, thereby helping to protect against age-related brain deficits and neurodegeneration.⁴⁹

The PI for anthocyanidins was found to be 11.2 mg/day. Among adults 19 years and older, 13% meet this PI, which means 87% fall short. Graph 9 shows the percent of Americans, by age group, who have a gap in their anthocyanidins consumption.

Resveratrol

Resveratrol is found in grapes, which produce it as a defense against fungi. Wine is a major source of resveratrol in the diet, but resveratrol is also found in cocoa, dark chocolate and peanuts.

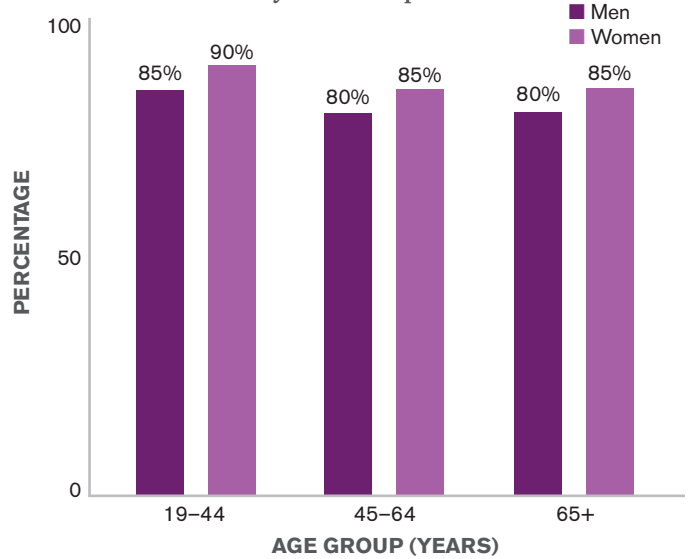
Resveratrol has been shown to improve endothelial function and to reduce oxidative stress in people with type II diabetes,⁵⁰ and is believed to aid in the prevention and treatment of common clinical conditions of aging including antioxidant defense, regulation of the cell cycle, mitochondrial energy production, cancer gene suppression and related phenomena typically associated with aging.⁵¹

The PI for resveratrol, excluding wine, was found to be 0.49 mg/day. Among adults 19 years and older, 11% meet this PI, which means 89% fall short. Graph 10 shows the percent of Americans, by age group, who have a gap in their resveratrol consumption.

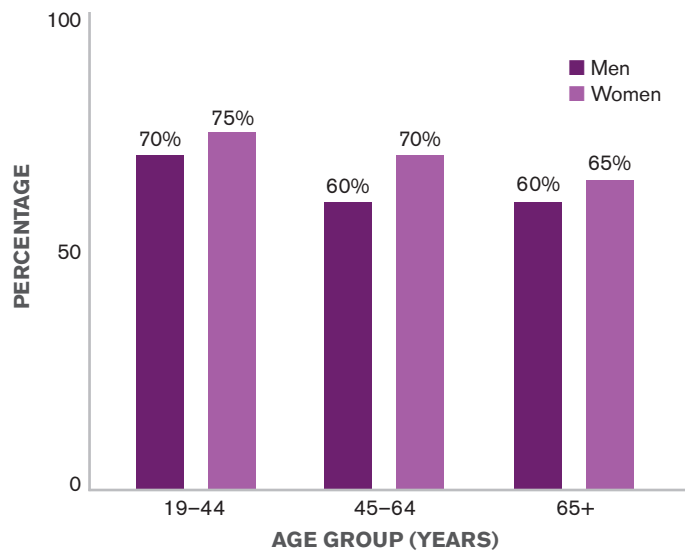
The Purple/Blue Group Summary

The average percent of Americans who fail to meet their anthocyanidins PI is 87% across all age groups. Excluding wine, the average percent of Americans who fail to meet their resveratrol PI is 89% across all age groups. Therefore, on average, approximately 88% $[(87+89)/2]$ of Americans fail to meet their phytonutrient intake within the purple/blue phytonutrient color grouping.

Graph 9: Percentage of Americans with Anthocyanidins Gap



Graph 10: Percentage of Americans with Resveratrol Gap (Excluding Wine)



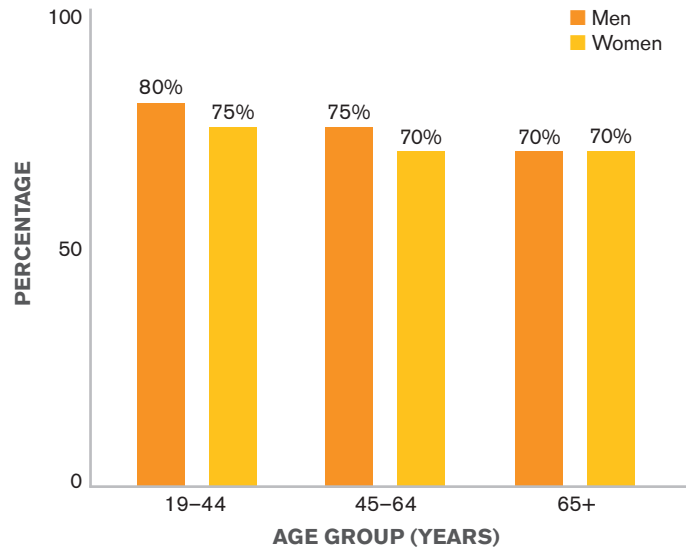
THE YELLOW/ORANGE GROUP

Alpha-Carotene

Alpha-carotene, like beta-carotene and beta-cryptoxanthin, are provitamin A carotenoids, meaning they can be converted by the body to vitamin A. Food sources include orange foods like pumpkin and carrots. Low circulating levels of carotenoids have been associated with cardiovascular disease. Both alpha and beta-carotene have been shown to be inversely associated with 15-year cardiovascular disease mortality in elderly men.⁵²

The PI for alpha-carotene was found to be 518 mcg/day. Among adults 19 years and older, 23% meet this PI, which means 77% fall short. Graph 11 shows the percent of Americans, by age group, who have a gap in their alpha-carotene consumption.

Graph 11: Percentage of Americans with Alpha-Carotene Gap

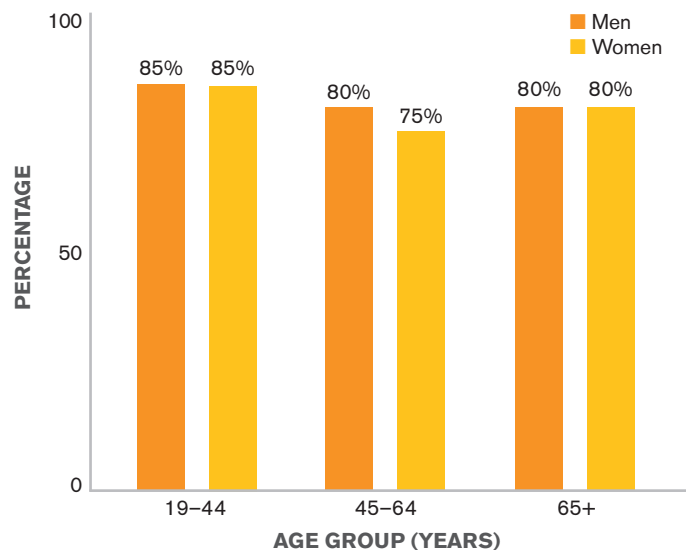


Beta-Carotene

Beta-carotene is found in many orange fruits and vegetables like cantaloupe, carrots and sweet potatoes. Beta-carotene is a powerful antioxidant, protecting the cells of the body from damage caused by free radicals. It is also one of the carotenoids believed to enhance the function of the immune system,⁵³ and may play a protective role in bone health.⁵⁴

The PI level of intake for beta-carotene was found to be 3787 mcg/day. Among adults 19 years and older, 16% meet this PI, which means 84% fall short. Graph 12 shows the percent of Americans, by age group, who have a gap in their beta-carotene consumption.

Graph 12: Percentage of Americans with Beta-Carotene Gap



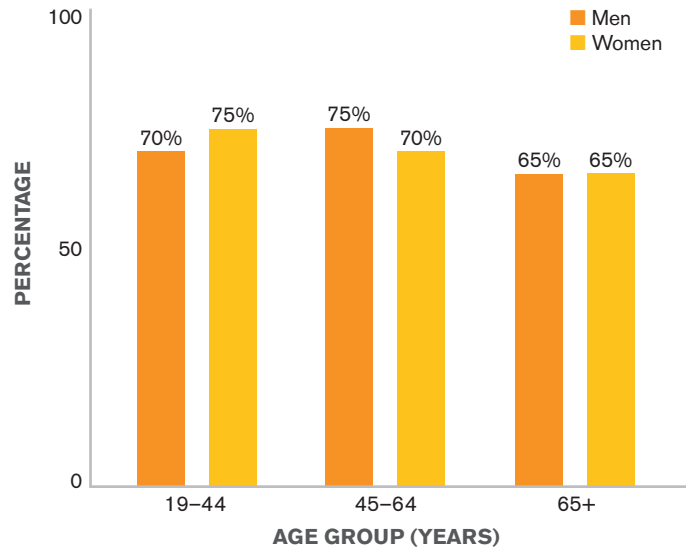
Hesperitin

Hesperidin is a flavanone glycoside consisting of the flavone hesperitin bound to the disaccharide rutinose. Because the USDA flavonoid database quantifies hesperitin (not hesperidin), this report uses hesperitin, which is mainly found in citrus fruits such as lemons and oranges.

Hesperitin is a flavonoid, and flavonoids are effective antioxidants and may protect against several chronic diseases. Epidemiological evidence indicates the incidence of cerebrovascular disease was lower at higher intakes of hesperitin, and the incidence of asthma was lower at higher total flavonoid intakes including hesperitin.⁵⁵

The PI level of intake for hesperitin was found to be 0.9 mg/day. Among adults 19 years and older, 27% meet this PI, which means 73% fall short. Graph 13 shows the percent of Americans, by age group, who have a gap in their hesperitin consumption.

Graph 13: Percentage of Americans with Hesperitin Gap

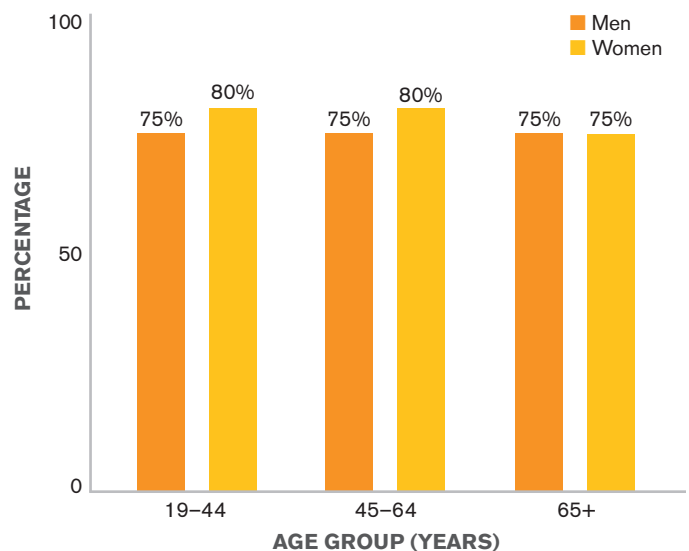


Beta-Cryptoxanthin

Beta-cryptoxanthin is found in vegetables like pumpkin, squash, peppers and fruits like tangerines. Epidemiologic studies suggest that the antioxidant potential of dietary carotenoids may protect against the oxidative damage that can result in inflammation. Research shows that a modest increase in beta-cryptoxanthin intake, equivalent to one glass of freshly squeezed orange juice per day, is associated with a reduced risk of developing inflammatory disorders such as rheumatoid arthritis.⁵⁶

The PI level of intake for beta-cryptoxanthin was found to be 223 mcg/day. Among adults 19 years and older, 20% meet this PI, which means 80% fall short. Graph 14 shows the percent of Americans, by age group, who have a gap in their beta-cryptoxanthin consumption.

Graph 14: Percentage of Americans with Beta-Cryptoxanthin Gap



The Yellow/Orange Group Summary

The average percent of Americans who fail to meet their alpha-carotene PI is 77% across all age groups. The average percent of Americans who fail to meet their beta-carotene PI is 84% across all age groups. The average percent of Americans who fail to meet their hesperitin PI is 73% across all age groups. The average percent of Americans who fail to meet their beta-cryptoxanthin PI is 80% across all age groups. Therefore, on average, approximately 78.5% $([77+84+73+80]/4)$ of Americans fail to meet their phytonutrient intake within the orange/yellow phytonutrient color grouping.



Eating by Color

The Gap by Color

Collectively, the phytonutrient gaps in consumption in terms of the percent of Americans not meeting their PIs are as follows (see table 5):

Table 5: The Phytonutrient Gaps by Color

COLOR CATEGORY	PHYTONUTRIENT	PERCENT MEETING PI	AVERAGE PERCENT MEETING PI*	AVERAGE PERCENT NOT MEETING PI*
GREEN	EGCG	35	31	69
	Isothiocyanate	36		
	Lutein/zeaxanthin	17		
	Isoflavones	37		
RED	Lycopene	31	22	78
	Ellagic Acid	13		
WHITE	Allicin	15	15	86
	Quercetin	14		
PURPLE/BLUE	Anthocyanidins	13	12	88
	Resveratrol	11		
YELLOW/ORANGE	Alpha-carotene	23	22	79
	Beta-carotene	16		
	Hesperitin	27		
	Beta-cryptoxanthin	20		

*Due to rounding, percents above and below PI may not total exactly 100 percent.

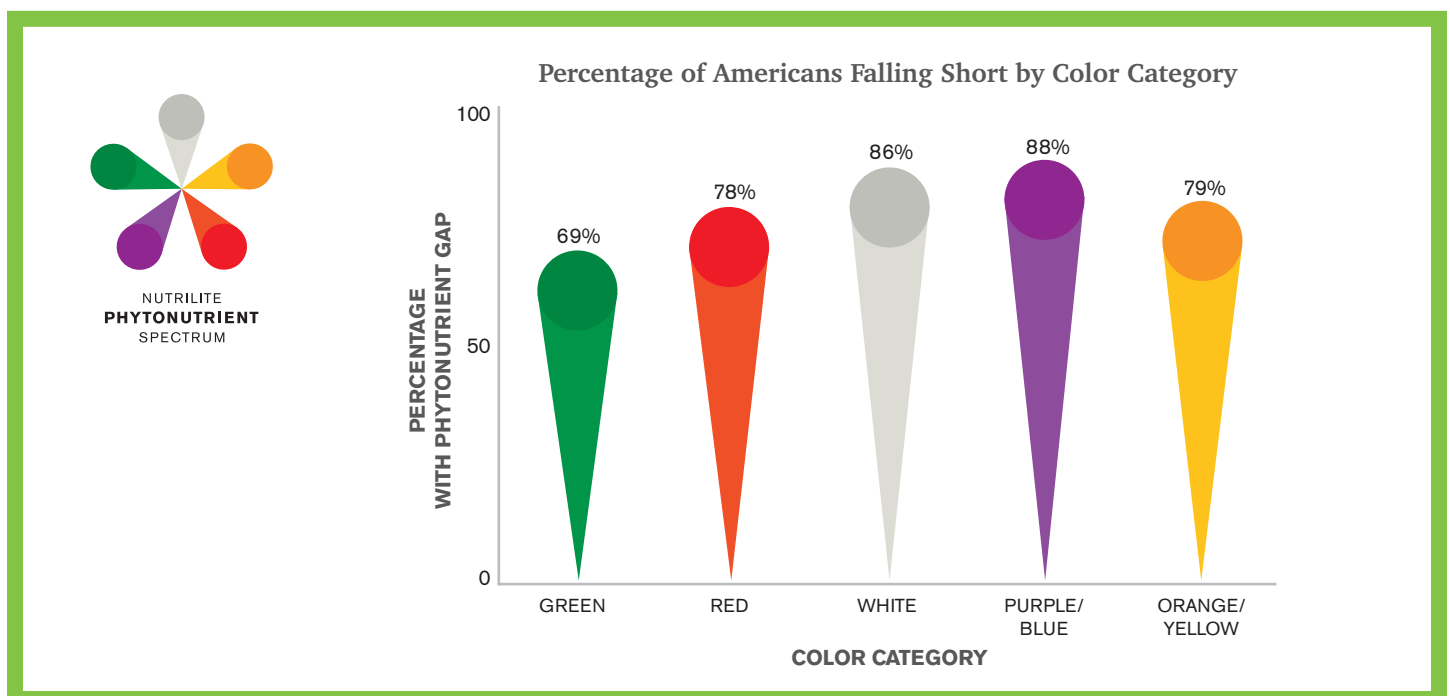
Filling the Gap

Based on the analyses of this report, Americans are falling short in virtually every color category of phytonutrients:

- ▶ 69% fall short in green
- ▶ 78% fall short in red
- ▶ 86% fall short in white
- ▶ 88% fall short in purple/blue
- ▶ 79% fall short in yellow/orange

The biggest "gap" is among the purple/blue (only 12% meet "prudent intake" levels), while Americans are doing somewhat better in the "green" category (31% meet "prudent intake" levels).

Therefore, on average, 8 out of 10 Americans have a phytonutrient gap. Ideally, Americans should seek approximately 10 servings of fruits and vegetables daily, which could be interpreted as 2 servings from each color category presented. While the exact balance of servings per color could be debated among health and nutrition professionals, the goal of having Americans consume 2 servings from each color category for a total of 10 servings is easy and straightforward for consumers to follow. A simple message of whole foods first is important, along with the message to choose richer and more vibrantly colored foods whenever possible. Beyond this, dietary supplementation may be an option for individuals looking to reduce their phytonutrient gap.



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