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AMERICA'S PHYTONUTRIENT REPORT

WOMEN'S HEALTH BY COLOR

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Executive Summary

Most Americans have intakes of fruit and vegetables that fall below minimum recommended intakes. Consequently, most Americans may be falling short in key nutrients found in fruit and vegetables, including phytonutrients. Based on data presented in *America's Phytonutrient Report: Quantifying the Gap*, on average, 8 out of 10 American adults (76%) have a "phytonutrient gap."

As stated in that previously released report, the "phytonutrient gap" is defined as the percentage of the adult population with phytonutrient intakes less than the median intake by adults who meet government guidelines for recommended daily intakes of fruits and vegetables ("meeters"). In other words, the "gap" represents the shortfall of phytonutrient intakes based on a typical level of phytonutrient intake consistent with a diet that is considered to have a prudent amount of fruits and vegetables.

More specifically, a strong majority of Americans are falling short in virtually every color category of phytonutrients:

- 69% fall short in green
  Includes EGCG, isothiocyanates, lutein/zeaxanthin, and isoflavones
- 74% fall short in red
  Includes lycopene and ellagic acid
- 83% fall short in white
  Includes allicin and quercetin
- 76% fall short in purple/blue
  Includes anthocyanidins and resveratrol
- 80% fall short in yellow/orange
  Includes alpha-carotene, beta-carotene, hesperitin, and beta-cryptoxanthin

The present extension report entitled *America's Phytonutrient Report: Women's Health by Color* explores patterns of phytonutrient intakes among adult women in different age groups, with particular attention to a category of phytonutrients called carotenoids, which are concentrated in fruits and vegetables, and have been shown to be beneficial to several women's health outcomes. The carotenoids of interest for this report fall into three of the color categories as follows:

- **Green** – lutein/zeaxanthin
- **Red** – lycopene
- **Yellow/Orange** – alpha-carotene, beta-carotene and beta-cryptoxanthin

For the purposes of these analyses, women have been grouped into "older women" (45 years and older) and "younger women" (19-44 years old). Key findings based on energy-adjusted data include:

- Older women have total carotenoid intakes that are 20% greater than those of younger women, suggesting a more pronounced "carotenoid gap" or shortfall among younger women.
  - Calorie for calorie, older women consume 50% more beta-carotene, 40% more of both lutein/zeaxanthin and alpha-carotene and 10% more beta-cryptoxanthin.
  - Calorie for calorie, older and younger women consume comparable amounts of lycopene.
- Average carotenoid intakes are driven largely by the consumption of a small number of common foods which are not always the most concentrated source of a given carotenoid.
  - Cooked pumpkin is a concentrated source of alpha-carotene, beta-carotene and beta-cryptoxanthin, but accounts for no more than 3% of the intake of any of these carotenoids.
  - Spinach is the most common food source of lutein/zeaxanthin among American women, while kale accounts for no more than 3% of intake. However, kale offers triple the lutein/zeaxanthin compared to an equivalent serving of spinach.

Overall, consuming a wide variety of the most phytonutrient-rich whole fruits and vegetables is the primary dietary goal. Given the shortfall of carotenoid intakes, it is prudent for women of all ages to focus on increasing both the quantity and quality of carotenoid-rich foods. Beyond this, a natural plant-based dietary supplement is an option for those women wishing to address their "phytonutrient gap" as well as their "carotenoid gap."

Nutrilite's *America's Phytonutrient Report: Women's Health by Color* was developed from analyses of dietary recall and health examination data from the National Health and Nutrition Examination Survey (NHANES), ongoing surveys designed to assess the health and nutritional status of the U.S. population, and supplemental nutrient concentration data from the United States Department of Agriculture (USDA) and the published literature. These analyses were completed by Exponent for Nutrilite in July 2010.

Introduction

Despite some data showing only a modest association between overall cancer risk and high intake of fruits and vegetables,[1] the 2007 World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) report advises people to "eat mostly foods of plant origin" for cancer prevention.[2] The landmark, global report concluded that those diets most protective against cancer are comprised mainly of plant-based foods, including fruits and vegetables.

While the detailed mechanisms tracking to specific plant nutrients are the subject of ongoing research and debate, it is widely believed that the health benefits of diets high in fruit and vegetables are likely to be due in part to the presence of phytonutrients, including carotenoids, which are bioactive substances. In turn, the reduced cancer risk conferred may operate in varied mechanisms including, but not limited to antioxidant, antiproliferative or other cellular or hormonal events.

Based on the data presented in the original *America's Phytonutrient Report: Quantifying the Gap*,[3] only 3% of women ages 19-44 and 9% of women ages 45-64 meet their fruit and vegetable intake recommendations. Women over 65 years old are doing the best with 12% meeting their intake recommendations, but this is still a very small percentage of the total population. The present analyses take the concept of the "phytonutrient gap" from the original report, and extend it to the notion of a "carotenoid gap" among women.

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Fruit and vegetables are considered to be important means of preventing cancer through diet. Several recent large prospective cohort studies and clinical trials have found no associations regarding different major cancer types.[4] However, with respect to breast and ovarian, the population-based literature points in general terms to a beneficial effect of fruit and vegetable consumption. For example, a meta-analysis of 26 published studies from 1982 to 1997 showed that women with the highest consumption of vegetables had a 25% reduced risk of breast cancer compared to those with lower intakes.[5] Similarly, research on ovarian cancer has also shown a protective effect for increased vegetable consumption. In several case-control studies conducted in China,[6] Sweden[7] and the US,[8] a risk reduction of 24%, 39% and 53% respectively was achieved for women who consumed the greatest amount of vegetables compared to those who consumed the least.

Given the importance of fruit and vegetable consumption in relation to optimal health, this report documents carotenoid intakes among younger and older women, and examines the common food sources of carotenoids in the American diet. While relatively few studies to date have considered individual phytonutrients in relation to specific disease subtypes, this report shares some existing literature on carotenoids in relation to breast and ovarian health for illustrative purposes. Certainly there are many other aspects to total women's health not covered here.

The "Phytonutrient Gap" Defined

Because phytonutrients are not considered "essential" to human health, there are no corresponding Dietary Reference Intakes (DRIs) like there are for the macro and micronutrients. To be clear, the *America's Phytonutrient Report* research series is not designed to determine the ideal or even adequate intake level of any phytonutrient. Rather, the reports are based on the identification of the median dietary intake of phytonutrients by the subpopulation of adults who meet their fruit and vegetable intake recommendations ("meeters") compared to those who fail to meet recommended intakes ("non-meeters").

The "phytonutrient gap" is defined as the percent of the total population of adults with phytonutrient intakes less than the median intake for the select phytonutrients of interest. In other words, this "gap" represents the shortfall of phytonutrient intakes based on a reference level of phytonutrient intake consistent with a "prudent diet" which is high in fruits and vegetables. It is important to point out that a "prudent diet" may still fall short of desirable or optimal levels of some or even most phytonutrients found in fruits, vegetables, and other plant sources such as teas and nuts.

The "phytonutrient gaps" by color based on the original report are listed in Table 1.

Table 1: "Phytonutrient Gaps" by Color Category

COLOR CATEGORY	PHYTONUTRIENT	PERCENT OF AMERICAN ADULTS WITH A PHYTONUTRIENT GAP
GREEN	EGCG	69
	Isothiocyanates	
	Lutein/zeaxanthin	
	Isoflavones	
RED	Lycopene	74
	Ellagic Acid	
WHITE	Allicin	83
	Quercetin	
PURPLE/ BLUE	Anthocyanidins	76
	Resveratrol	
YELLOW/ ORANGE	Alpha-carotene	80
	Beta-carotene	
	Hesperitin	
	Beta-cryptoxanthin	

The "Carotenoid Gap"

Dietary recommendations by the National Cancer Institute, American Cancer Society and American Heart Association encourage the consumption of a variety of fruits and vegetables daily, and are certainly aimed, in part, at increasing carotenoid intake. Yet, after reviewing the published scientific research in 2000, the Food and Nutrition Board of the Institute of Medicine concluded that the existing evidence was insufficient to establish a recommended dietary allowance (RDA) or adequate intake (AI) for carotenoids. Therefore, this report does not attempt to quantify a shortfall in carotenoid consumption in micrograms, but rather compares carotenoid intakes of older versus younger women in order to determine relative intakes. Results from previous analyses indicate that carotenoid intakes by most adults are below intakes by adults meeting fruit and vegetable recommendations ("meeters"), indicating that there is a "carotenoid gap" for many Americans. Differences in energy-adjusted carotenoid intakes between older and younger women provide a measure of the relative magnitude of the "carotenoid gap" for these two subpopulations of women.

The carotenoids included in this report span the green, red and yellow/orange categories as show in Table 2.

Table 2: Phytonutrients for Women's Health – The Carotenoids

GREEN	Lutein/zeaxanthin
RED	Lycopene
YELLOW/ORANGE	Alpha-carotene, Beta-carotene, Beta-cryptoxanthin

Carotenoids can be broadly classified into two groups: carotenes (alpha-carotene, beta-carotene, and lycopene) and xanthophylls (beta-cryptoxanthin, lutein, and zeaxanthin). Alpha-carotene, beta-carotene, and beta-cryptoxanthin are provitamin A carotenoids, meaning they can be converted by the body to retinol (vitamin A). Lutein/zeaxanthin and lycopene have no vitamin A activity.

Methodology & Data Sourcing

America's Phytonutrient Report: Quantifying the Gap[3] looked at 14 select phytonutrients including carotenoids (lutein/zeaxanthin, lycopene, alpha-carotene, beta-carotene, beta-cryptoxanthin), flavonoids (anthocyanidins, epigallocatechin 3-gallate [EGCG], hesperitin, quercetin), phenolics (ellagic acid, resveratrol), isothiocyanates, isoflavones and allicin in order to determine gaps in consumption. Estimated phytonutrient intakes were developed from food consumption recall data collected in the National Health and Nutrition Examination Survey (NHANES) 2003-2006,[9,10] and available nutrient concentration data. The USDA's Food and Nutrient Database for Dietary Studies 3.0 (FNDDS 3)[11] was the primary source of carotenoid concentration data for each food reported in NHANES; values from FNDDS 2 were used for foods consumed only in the period 2003-2004.[12] The USDA flavonoid database was used to identify concentrations of anthocyanidins, EGCG, hesperitin and quercetin[13] and USDA's isoflavone database was used to identify concentrations of total isoflavones in each food as reported.[14] Concentration data for ellagic acid, resveratrol, isothiocyanates, and allicin were developed from the published literature. Estimated intakes of all of the phytonutrients were limited to the food forms (e.g., raw, cooked, canned) for which the phytonutrient concentration data were determined to be applicable. The analyses in this report utilize 2-day average intakes from dietary recalls, and are not necessarily indicative of long-term intakes.

Consistent with the previous analyses, a "meeter" was defined as an individual who consumed the age- and sex-specific recommendations for fruit and vegetable servings as detailed in the MyPyramid dietary guidance system (mypyramid.gov) based on the two days of dietary intake collected in NHANES 2003-2006. The "non-meeter" category therefore represents individuals who failed to meet the recommended intakes for the fruit group, the vegetable group, or both groups.

The Study Population

A total of 8072 adults age 19 years and older in the survey period 2003-2006 provided two complete days of dietary recalls. The sample includes data from 3988 non-pregnant, non-lactating females and 4084 males. The analyses in this report are based on recalls from the 3988 females.

Among the women in the sample population, 307 were classified as "meeters" and 3681 were classified as "non-meeters." For the previous reports, subpopulations of adults included women age 19-44 years, age 45-64 years, and age 65+ years. In the current analyses, the subpopulation of 1673 women age 19-44 years corresponds to the "younger women" subpopulation. Women age 45-64 years and women 65+ years were combined into a single category of 2315 "older women" (45 years and older). This category of younger women approximates pre-menopausal women, while the category of older women roughly corresponds to peri- and post-menopausal women.

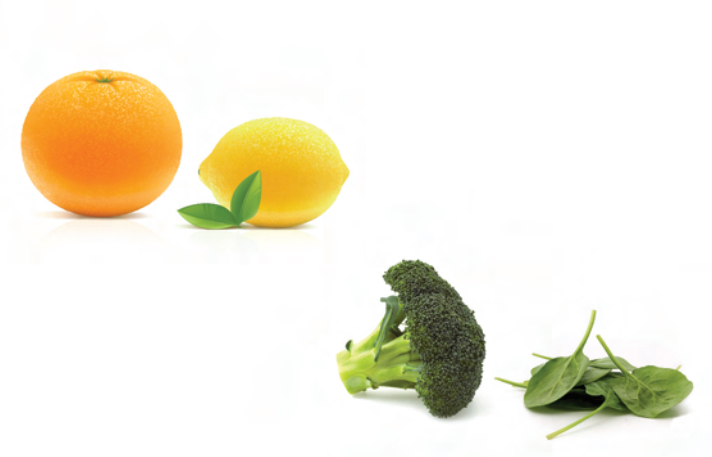
Data Results

Based on these analyses, the mean carotenoid intakes among "meeters" and "non-meeters" using 2-day average intakes are shown in Table 3. Data are energy-adjusted to account for differences in energy intake by different populations (mcg carotenoids/1000 kcal/day). As shown, calorie for calorie, carotenoid intakes were consistently higher by "meeters" compared to "non-meeters."

Table 3: Energy-Adjusted Carotenoid Intake Among "Meeters" and "Non-Meeters"*

CAROTENOID	"MEETERS" (N=307)	"NON-MEETERS" (N=3681)
LUTEIN/ZEAXANTHIN	1732	864
LYCOPENE	4090	2555
ALPHA-CAROTENE	491	219
BETA-CAROTENE	2917	1206
BETA-CRYPTOXANTHIN	135	71
TOTAL CAROTENOIDS	9366	4915

**Values given in mcg carotenoids/1000 kcal/day; total may not equal sum of individual values due to rounding.*



The mean intakes comparing younger and older women using 2-day average intakes are shown in Table 4. Data are energy-adjusted (mcg carotenoids/1000 kcal/day). As shown, calorie for calorie, older women had consistently higher intakes of carotenoids than did younger women.

Table 4: Energy-Adjusted Carotenoid Intake Among Younger and Older Women*

CAROTENOID	YOUNGER WOMEN (N=1673)	OLDER WOMEN (N=2315)
LUTEIN/ZEAXANTHIN	758	1059
LYCOPENE	2639	2681
ALPHA-CAROTENE	191	276
BETA-CAROTENE	1027	1565
BETA-CRYPTOXANTHIN	70	80
TOTAL CAROTENOIDS	4685	5660

**Values given in mcg carotenoids/1000 kcal/day; total may not equal sum of individual values due to rounding.*

The intake of carotenoids as measured in terms of "carotenoid density" was compared between the older and younger women. The ratio of "carotenoid density" where younger women are considered the reference group is shown in Table 5. Ratios greater than 1.0 indicate that subpopulations of older women consumed a more carotenoid dense diet compared to younger women, while ratios equal to 1.0 indicate that calorie for calorie, similar amounts of carotenoids were consumed.

Calorie for calorie, carotenoid intakes were **consistently higher** by "meeters" compared to "non-meeters."

Table 5: Ratios of Energy-Adjusted Carotenoid Intakes Versus Younger Women's Intakes

CAROTENOID	YOUNGER WOMEN (REFERENCE GROUP)	OLDER WOMEN VS. YOUNGER WOMEN
LUTEIN/ZEAXANTHIN	1.0	1.4
LYCOPENE	1.0	1.0
ALPHA-CAROTENE	1.0	1.4
BETA-CAROTENE	1.0	1.5
BETA-CRYPTOXANTHIN	1.0	1.1
TOTAL CAROTENOIDS	1.0	1.2

Results of these analyses show that older women consumed 20% more total carotenoids per 1000 kcal as compared to younger women (ratio = 1.2). Specifically, calorie for calorie, older women consumed 50% more beta-carotene (ratio = 1.5), 40% more lutein/zeaxanthin and alpha-carotene (ratio = 1.4), and 10% more beta-cryptoxanthin (ratio = 1.1). Older and younger women consumed comparable amounts of lycopene (ratio = 1.0) calorie for calorie.

Calorie for calorie, older women consumed **20%** more total carotenoids as compared to younger women.

Carotenoid Findings by Color Category

The following sections outline each carotenoid within the three color categories (green, red, and yellow/orange), and include a brief summary of the existing peer-reviewed literature with an emphasis on breast and ovarian cancers. Additionally, this report identifies top food sources for each carotenoid based on consumption patterns reported by younger and older American women.

THE GREEN GROUP

Lutein/Zeaxanthin

Lutein/zeaxanthin are carotenoids that offer a high level of antioxidant activity. Zeaxanthin is a carotenoid pigment that is derived from lutein. Women "meeters" had more than double the energy-adjusted intakes of lutein/zeaxanthin when compared to women "non-meeters." As shown in Table 5, older women had 40% higher energy-adjusted intakes of lutein/zeaxanthin than younger women.

Research Highlights: Carotenoids have been shown to be protective against certain cancers in part through their antioxidant and antiproliferative properties. For example, in a large, population-based study examining the risk factors for invasive breast cancer, results showed a decreased breast cancer risk among premenopausal women with increasing intakes of lutein/zeaxanthin,[15] which aligns with previous research findings.[16] Strong associations with increased intakes of lutein/zeaxanthin were also seen in premenopausal women with a positive family history of breast cancer.[17] Additionally, decreased risks for ovarian cancer have been observed with increasing intakes of lutein/zeaxanthin among both premenopausal and postmenopausal women.[18]

Food Sources Among American Women: Lutein/zeaxanthin are found in green, leafy vegetables such as spinach, salad greens and kale. Spinach was the top source of lutein/zeaxanthin for younger and older women, accounting for a little over 30% of total intake. In both age groups of women, salad greens (e.g., lettuce) ranked second, broccoli third, and collard greens fourth. Each of these foods accounted for 4-7% of total lutein/zeaxanthin intake. Some other foods that provided 2-4% of intake by both younger and older women included oranges and orange juice, green peas, summer squash, and sweet yellow corn.

THE RED GROUP

Lycopene

Lycopene is a carotenoid that exhibits potent antioxidant activity. In terms of cancer prevention, lycopene has been shown to inhibit cell cycle progression in a similar manner to many anticancer drugs such as tamoxifen, progestins, retinoids and vitamin D_3.[19] As shown in Table 3, women "meeters" had energy-adjusted intakes of lycopene approximately 50% more than "non-meeters." However, no differences were identified between younger and older women in terms of energy-adjusted lycopene intake.

Research Highlights: There have been several studies that showed the positive effects of lycopene on breast and ovarian cancer risk reduction. In a case-control study, women in the highest quintile of lycopene intake had approximately half the risk of developing breast cancer compared to women in the lowest quintile.[20] Similar results were found in a large population-based, case-control study of postmenopausal women that showed a 34% reduction in risk for the women in the highest intakes of lycopene compared to those with the lowest.[21] With respect to ovarian cancer, premenopausal women participating in a population-based, case-control study had a 63% reduction in the occurrence of ovarian cancer for the highest intakes of lycopene compared with the lowest.[22] This risk reduction was primarily due to consumption of tomato sauce; women consuming at least two half cup servings per week had a 40% decrease in risk for ovarian cancer.

Food Sources Among American Women: Lycopene is found in tomatoes and tomato products, as well as in fruits such as watermelon and pink/red grapefruit. In these analyses, tomatoes and tomato products, including tomatoes in vegetable mixtures, tomato-based soups/stews, and tomato-based mixtures such as pizza accounted for the majority of the dietary lycopene intake for American women; in younger women, these foods accounted for 93% of lycopene intake and in older women, 89%. Consumption of watermelon contributed 5% and 9% of lycopene intake for younger and older women respectively.

THE YELLOW/ORANGE GROUP

Alpha-carotene

Carotenoids such as alpha-carotene can be converted into vitamin A. They are believed to be important in cancer prevention because of their properties as antioxidants and their ability to affect cell differentiation or proliferation.[23] Energy-adjusted alpha-carotene intake was more than double among women "meeters" compared to "non-meeters." As shown in the Table 5, older women had energy-adjusted intakes 40% higher than those of younger women.

Research Highlights: Consumption of alpha-carotene may be associated with a reduced risk of breast cancer in some women, with data most supportive among premenopausal women. For example, a large prospective study of carotenoid intakes and breast cancer risk showed an inverse relationship for premenopausal women with a family history of breast cancer.[24] A study using the Women's Health Initiative data set also showed an inverse relationship between serum alpha-carotene levels and breast cancer incidence.[25] Another study found women consuming more than 413 mcg/day of alpha-carotene, had a 27% reduction in breast cancer incidence compared with women having intakes between 0-79.9 mcg/day, though these results only trended towards significance.[26] In terms of ovarian cancer, one study found that postmenopausal women had a 58% reduction in risk with the highest consumption of alpha-carotene compared with the lowest.[22] More specifically, the women consuming five or more servings of raw carrots per week had a 54% risk reduction.

Food Sources Among American Women: Alpha-carotene is found in a number of foods including carrots, pumpkin, winter squash and plantains. Dietary sources of alpha-carotene for adult women in these analyses show that the predominant source of alpha-carotene was carrots which accounted for 76% and 73% of total intake for younger and older women respectively. Vegetable mixtures ranked second, followed closely by tomatoes (5-7% of intakes). Non-tomato-based soups and stews as well as pumpkin accounted for 2-4% of total alpha-carotene intake by younger and older women.

Beta-carotene

Beta-carotene affects cell growth regulation, including the inhibition of growth and malignant transformation of cells.[27] More specifically, beta-carotene has been shown to inhibit both estrogen receptor (ER)-positive and ER-negative breast tumor growth in cells, as well as inhibit estrogen-induced cell proliferation.[28] Findings from the current analysis show that women "meeters" reported consuming more than double the energy-adjusted beta-carotene than "non-meeters," while older women consumed approximately 50% more beta-carotene than younger women at comparable energy intakes.

Research Highlights: While beta-carotene has shown positive protective effects against breast cancer, the results appear mixed in part based on menopausal status. Among premenopausal women (though not postmenopausal women), high intakes of beta-carotene resulted in decreased breast cancer risk compared to women with low intakes.[15] Further adjustments for both alcohol intake (<2 drinks per week) and reports of ever having smoked showed similar results in the group with the highest intakes of beta-carotene. In a different study among postmenopausal women, there was a decrease in risk for those consuming the highest amounts of beta-carotene compared to the lowest, with significant risk reduction in those consuming the greatest total amounts of fruits and vegetables.[21] More specifically, risk reduction of 35% compared to 8% was achieved for those with ER-positive tumors compared to those with ER-negative tumors. Lastly, in terms of ovarian cancer, a 20% decrease in risk was observed for those consuming the highest amounts of beta-carotene compared to those consuming the lowest.[18]

Food Sources Among American Women: Beta-carotene is found in many orange fruits and vegetables, from carrots to pumpkin. Similar to alpha-carotene, carrots ranked as the number one source of this carotenoid in both age categories, accounting for 33% of total beta-carotene intake by younger women and 30% by older women. However, differences existed between younger and older women with respect to what other foods comprised their top food sources. Spinach ranked second for younger women accounting for 12% of beta-carotene intake, followed by tomatoes which accounted for 9% of intake. With respect to older women, sweet potatoes were the second greatest food source (12%), followed by spinach (11%) and tomatoes (6%). Some of the other foods providing at least 2% of beta-carotene intakes included salad greens, vegetable mixtures, collards, cantaloupe, and non-tomato based soups/stews.

Beta-cryptoxanthin

Because of their antioxidant properties, dietary carotenoids such as beta-cryptoxanthin, can neutralize reactive oxygen species, reduce genetic mutations and reduce oxidative damage,[29] all of which may help to protect against cancer. Preformed vitamin A (e.g., retinol and retinyl esters) is involved in cell differentiation; certain carotenoids such as beta-cryptoxanthin can be metabolized into retinol.[30] In terms of beta-cryptoxanthin intake among women in these analyses, "meeters" consumed almost twice as much energy-adjusted beta-cryptoxanthin as "non-meeters." Table 5 shows that older and younger women consume nearly similar amounts of energy-adjusted beta-cryptoxanthin.

Research Highlights: While beta-cryptoxanthin has received less research attention compared to other carotenoids, there is some evidence of an effect on breast cancer among postmenopausal women.[15] Results from the Women's Health Initiative, a longitudinal prospective study, showed that serum beta-cryptoxanthin levels were significantly lower in women who had a diagnosis of breast cancer at the six year point compared to those who did not, suggesting a possible relationship between beta-cryptoxanthin and breast health.[25] In another study, there was risk reduction of 46% for ovarian cancer in premenopausal women who consumed the highest amount of beta-cryptoxanthin compared to those who consumed the least; however, the results did not reach statistical significance.[22]

Food Sources Among American Women: Beta-cryptoxanthin is found in orange and yellow vegetables such as pumpkin and corn, and in fruits like oranges and peaches. In terms of consumption, the primary source of beta-cryptoxanthin for both older and younger women was oranges and orange juice, which accounted for approximately 60% of intake. Several other foods contributed up to 5% of total beta-cryptoxanthin intakes for younger and older women, though relative rankings of these foods differed in the two groups. Papaya was the second highest source of beta-cryptoxanthin for younger women and contributed 5%, while papaya contributed less than 2% of intake for older women. Among older women, sweet yellow corn contributed 5%, though this food ranked sixth as a source of beta-cryptoxanthin for younger women at 4%. Other foods that provided between 2-5% of beta-cryptoxanthin for younger and older women included tangerines and tangerine juice, watermelon, cucumbers/pickles, red peppers and peaches.

Key Dietary Sources of Phytonutrients by Younger Versus Older Women

In order to better understand the dietary choices of younger women compared to older women with respect to phytonutrient intake, an investigation of contributions by food source was performed. These results, found in Table 6, show that younger and older women had the same top food source for each carotenoid examined. For lutein/zeaxanthin the top food source was spinach, and for lycopene it was tomato and tomato products. Within the yellow/orange color category, carrots were the top food source for both alpha-carotene and beta-carotene. For beta-cryptoxanthin, the top source was oranges/orange juice. Additionally, Table 6 provides an example of a highly concentrated food source of each carotenoid.

Table 6: Food Source Comparisons Between Younger Versus Older Women

CAROTENOID	HIGHLY CONCENTRATED FOOD SOURCE FOR EACH CAROTENOID	TOP FOOD SOURCE IN THE DIET (% CONTRIBUTION TO TOTAL INTAKE OF PHYTONUTRIENT)	
		YOUNGER WOMEN	OLDER WOMEN
LUTEIN/ZEAXANTHIN	Kale	Spinach (33%)	Spinach (31%)
LYCOPENE	Tomatoes/tomato products	Tomatoes/tomato products (93%)	Tomatoes/tomato products (89%)
ALPHA-CAROTENE	Carrots	Carrots (76%)	Carrots (73%)
BETA-CAROTENE	Sweet potato	Carrots (33%)	Carrots (30%)
BETA-CRYPTOXANTHIN	Pumpkin	Oranges/orange juice (61%)	Oranges/orange juice (60%)

Closing the "Carotenoid Gap"

Women of all ages should choose a wide variety of carotenoid-containing fruits and vegetables in order to close their "phytonutrient gap" which contains carotenoids.

Ideally, women of all ages should choose a wide variety of carotenoid-containing fruits and vegetables in order to close their "phytonutrient gap," which contains carotenoids. Results from these analyses suggest that calorie for calorie, younger women tend to have a larger shortfall in carotenoid intakes compared to older women. Dietary carotenoids require the presence of fat in a meal in order to be absorbed intestinally; as little as 3-5 grams of fat appears sufficient to ensure carotenoid absorption.[31] Chopping, puréeing, and cooking carotenoid-containing vegetables in oil generally increase the carotenoid bioavailability.

Overall, consuming a wide variety of the most phytonutrient-rich whole fruits and vegetables is the primary dietary goal. Given the shortfall of carotenoid intakes, it is prudent for women of all ages to focus on increasing both the quantity and quality of carotenoid-rich foods. Beyond this, a natural plant-based dietary supplement is an option for those women wishing to address their "phytonutrient gap" as well as their "carotenoid gap."

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