



Prevalence of Lutein Versus Lutein Esters in Human Diets

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Key Conclusions

- **93% of the total amount of lutein, zeaxanthin and their esters found in human diet are present as lutein and zeaxanthin and not as esters.**
- **Lutein esters and zeaxanthin esters, as found in marigold extract, are not the predominant sources of lutein and zeaxanthin found in a typical diet.**

Introduction

Everyday people are discovering the benefits of including important antioxidants in their diets to maintain better health. In particular, people concerned about Age-related Macular Degeneration (AMD), the leading cause of blindness in the industrialized world, are becoming aware of the benefits of lutein and zeaxanthin for reducing the risk of developing this disease. More recently, scientific studies indicate that lutein and zeaxanthin may also reduce the risk of other major chronic diseases such as breast cancer, skin cancer and cataracts. Lutein is the most abundant carotenoid present in green vegetables, such as spinach, kale, broccoli, Brussel sprouts and leaf lettuce. In fruits, lutein esters are present in small amounts and are esterified with either palmitic acid, stearic acid, oleic acid, myristic acid or other fatty acids. Lutein esters have not been found in abundance in human serum or plasma (Khachik *et al.* 1995a, Bone *et al.*, 1993); they must undergo hydrolysis in presence of digestive enzymes before they can be absorbed into the bloodstream (Khachik, *et al.* 1995b). This technical paper provides actual statistical data demonstrating that most of the lutein absorbed by the human body is present as lutein not lutein esters in our diets.

Methodology

Lutein and zeaxanthin content in fruits and vegetables

Lutein/zeaxanthin content in fruits and vegetables was taken from the USDA-NNCC Carotenoid Database for U.S. Foods (1998). This database was created by the United States Department of Agriculture (USDA) and the Nutrition Coordinating Center (NCC) at the University of Minnesota. The project was partially funded by the National Cancer Institute (NCI). Most values for lutein and zeaxanthin were reported as one. Where the zeaxanthin values were available, these values were subtracted from the total lutein/zeaxanthin content and expressed as lutein concentrations. In those cases where zeaxanthin numbers were

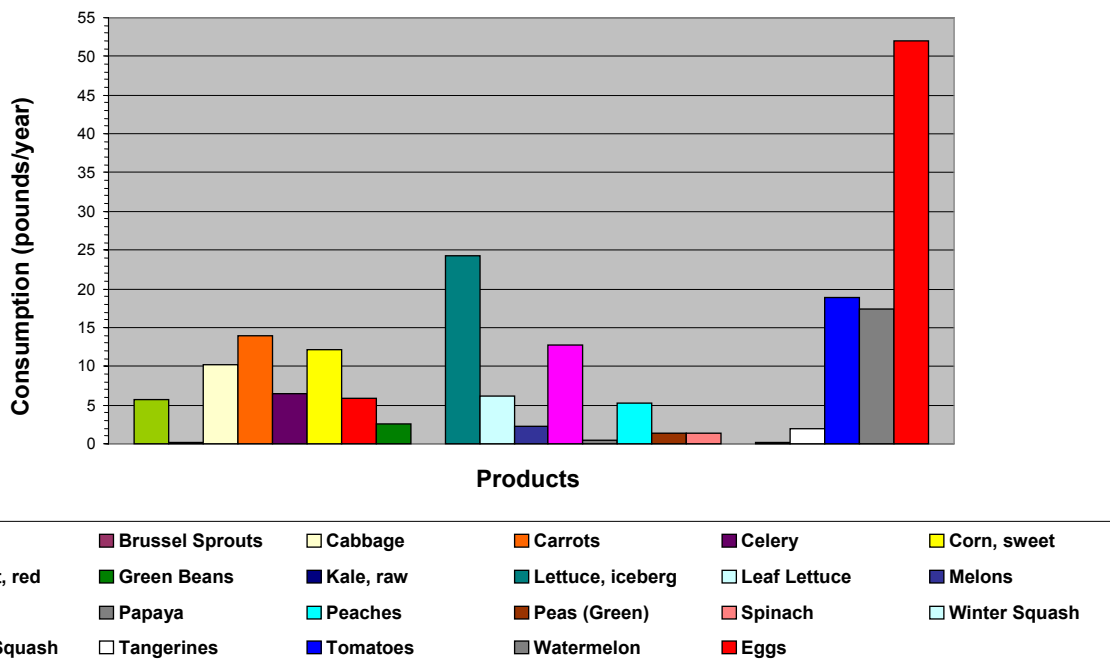
not reported, it was assumed that lutein/zeaxanthin values represented lutein. Since lutein is not found in most fruits (Khachik, *et al.* 1995b), it was also assumed that all the lutein/zeaxanthin values reported in this database for fruits represented lutein esters and zeaxanthin esters.

Per capita consumption of lutein, zeaxanthin and their esters in the United States

The per capita consumption of lutein, lutein esters, zeaxanthin and zeaxanthin esters in the USA for 1996 was calculated based on the per capita consumption of individual fruits, vegetables and eggs. Only fresh and frozen vegetables were included in this research. Cooked vegetables were purposely excluded because the amount of lutein present in these vegetables is dependent on cooking temperatures and rates, which may vary (USDA Statistics reports, 1999) (Figure 1).

To estimate the per capita consumption of these carotenoids and their esters, the per capita consumption for each fruit and vegetable (Figure 1) was multiplied by the average content of lutein, lutein esters, zeaxanthin or zeaxanthin esters reported on Table 1. The data are expressed in mg/year.

Figure. 1. Per Capita Consumption of Fruits, Vegetables and Eggs in the USA (1996).



From USDA statistics reports (1999)

Results

Table 1 shows the distribution of lutein, lutein esters, zeaxanthin and zeaxanthin esters in fruits, vegetables and eggs. Most of the lutein from the diet is found in green vegetables, particularly, kale and spinach. According to the data shown on Table 1 most of the per capita lutein intake comes from broccoli, spinach, leafy lettuce and iceberg lettuce. Lutein and zeaxanthin esters are present in very small amounts in fruits. The major contributors of lutein esters in a typical diet are tomatoes and oranges. This is true because of the high per capita consumption of these fruits per year, however these numbers only represent less than five percent of the total annual per capita consumption of lutein, zeaxanthin and their esters. Therefore, it is estimated that 80 percent of total per capita consumption of these carotenoids are found in nature as lutein and 13 percent as zeaxanthin (Figure 2). Only small amounts of lutein esters (5.6 percent) and zeaxanthin esters (1.4 percent) are present as such in our diets.

Table 1. Composition of Fruits, Vegetables & Eggs and Per Capita Consumption of Lutein, Lutein esters, Zeaxanthin & Zeaxanthin esters (1996).

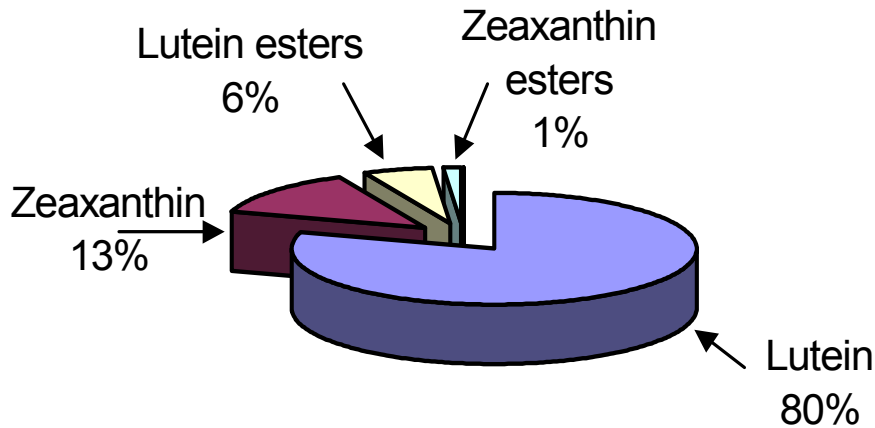
Fresh and frozen vegetables & eggs	Lutein (µg/100g)	Lutein Consumption (mg/year)*	Lutein ester (µg/100g)	Lutein esters Consumption (mg/year)*	Zeaxanthin (µg/100g)	Zeaxanthin Consumption (mg/year)*	Zeaxanthin esters (µg/100g)	Zeaxanthin esters Consumption (mg/year)*
Broccoli	2,422	62.68	-	-	23	0.60	-	-
Brussel Sprouts	1,590	0.79	-	-	-	-	-	-
Cabbage	310	14.36	-	-	-	-	-	-
Carrots, baby	335	21.29	-	-	23	1.46	-	-
Celery	229	6.71	-	-	3	0.09	-	-
Corn, sweet	356	19.72	-	-	528	29.24	-	-
Grapefruit, red	-	-	13	0.34	-	-	-	-
Green Beans	596	7.04	-	-	44	0.52	-	-
Kale, raw	39,377	1.79	-	-	173	0.01	-	-
Lettuce, iceberg	282	31.11	-	-	70	7.72	-	-
Leaf Lettuce	2,448	67.79	-	-	187	5.18	-	-
Melons	-	-	40	0.42	-	-	-	-
Oranges	-	-	113	6.57	-	-	74	4.30
Papaya	-	-	75	0.14	-	-	-	-
Peaches	-	-	51	1.20	-	-	6	0.14
Peas (Green)	1,292	8.21	-	-	58	0.37	-	-
Spinach	11,607	68.50	-	-	331	1.95	-	-
Winter Squash	-	-	38	0.01	-	-	-	-
Summer Squash	2,125	1.54	-	-	-	-	-	-
Tangerines	-	-	131	1.13	-	-	112	0.97
Tomatoes	-	-	130	11.15	-	-	-	-
Watermelon	-	-	17	1.34	-	-	-	-
Eggs	32	7.55	-	-	23	5.43	-	-
	-	-	-	-	-	-	-	-
Total	63,401	319	608	22	1,463	53	192	5.4

From USDA-NNCC Carotenoid Database for U.S. Foods (1998)

* These numbers were calculated based on the per capita consumption of Lutein and the amount of the carotenoids present in the products.

Figure 2. Prevalence of Lutein and Zeaxanthin in Fruits, Vegetables and Eggs in Human Diet.

Nebeling, *et al* (1997).



Nebeling, *et al* (1997) estimated that the average intake of Lutein/zeaxanthin was 2 mg/day. These calculations also included the contribution of lutein esters and zeaxanthin esters. However, based on the distribution of these carotenoids and their esters in fruit, vegetables and eggs, these esters only contribute to seven percent of the total intake of lutein and zeaxanthin, meaning that on average, people only consume 0.14 mg/day of lutein esters and zeaxanthin esters in their diet (Figure 2). Furthermore, because lutein esters and zeaxanthin esters must be de-esterified by the body in order to be absorbed, it is not clear the actual contribution to the total lutein content found in serum and deposited in body tissues these esters make.

It is also worthwhile mentioning that the results from this data are consistent with the low daily average consumption of lutein and zeaxanthin previously reported by Nebeling, *et al.* (1997). Furthermore, these numbers are much lower than the suggested lutein intake of 6 mg/day reported in the Journal of American Medical Association in 1994 by Dr. Seddon and co-workers. These researchers found a high correlation of AMD-disease prevention with an intake of 6 mg/day of lutein from spinach and other dark leafy vegetables. Therefore, they recommended a diet rich in lutein to lower the risk of developing AMD (Seddon, *et al.* 1994).

Conclusions

The results of this research demonstrate that 93 percent of the total amount of lutein, zeaxanthin and their esters found in fruit, vegetables and eggs are present as lutein and zeaxanthin and not as lutein esters or zeaxanthin esters. This is an important consideration when choosing to supplement our diets with lutein and zeaxanthin because some ingredients currently available in the market contain lutein esters and zeaxanthin esters. As this research demonstrates, lutein esters and zeaxanthin esters, as found in marigold extract, are not the predominant sources of lutein and zeaxanthin found in a typical diet.

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