

Intake of Carotenoids and Retinol in Relation to Risk of Prostate Cancer

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Background: Several human studies have observed a direct association between retinol (vitamin A) intake and risk of prostate cancer; other studies have found either an inverse association or no association of intake of β -carotene (the major provitamin A) with risk of prostate cancer. Data regarding carotenoids other than β -carotene in relation to prostate cancer risk are sparse. **Purpose:** We conducted a prospective cohort study to examine the relationship between the intake of various carotenoids, retinol, fruits, and vegetables and the risk of prostate cancer. **Methods:** Using responses to a validated, semiquantitative food-frequency questionnaire mailed to participants in the Health Professionals Follow-up Study in 1986, we assessed dietary intake for a 1-year period for a cohort of 47 894 eligible subjects initially free of diagnosed cancer. Follow-up questionnaires were sent to the entire cohort in 1988, 1990, and 1992. We calculated the relative risk (RR) for each of the upper categories of intake of a specific food or nutrient by dividing the incidence rate of prostate cancer among men in each of these categories by the rate among men in the lowest intake level. All *P* values resulted from two-sided tests. **Results:** Between 1986 and 1992, 812 new cases of prostate cancer, including 773 non-stage A1 cases, were documented. Intakes of the carotenoids β -carotene, α -carotene, lutein, and β -cryptoxanthin were not associated with risk of non-stage A1 prostate cancer; only lycopene intake was related to lower risk (age- and energy-adjusted RR = 0.79; 95% confidence interval [CI] = 0.64-0.99 for high versus low quintile of intake; *P* for trend = .04). Of 46 vegetables and fruits or related products, four were significantly associated with lower prostate cancer risk; of the four—tomato sauce (*P* for trend = .001), tomatoes (*P* for trend = .03), and pizza (*P* for trend = .05), but not strawberries—were primary sources of lycopene. Combined intake of tomatoes, tomato sauce, tomato juice, and pizza (which accounted for 82% of lycopene intake) was inversely associated with risk of prostate cancer (multivariate RR = 0.65; 95% CI = 0.44-0.95, for consumption frequency greater than 10 versus less than 1.5 servings per week; *P* for trend = .01) and advanced (stages C and D) prostate cancers (multivariate RR = 0.47; 95% CI = 0.22-1.00; *P* for trend = .03). No consistent association was observed for dietary retinol and risk of prostate cancer. **Conclusions:** These findings suggest that intake of lycopene or other compounds in tomatoes may reduce prostate cancer risk, but other measured carotenoids are unrelated to risk. **Implications:** Our findings support recommendations to increase vegetable and fruit consumption to reduce cancer in-

cidence but suggest that tomato-based foods may be especially beneficial regarding prostate cancer risk. [J Natl Cancer Inst 1995;87:1767-76]

Throughout the Western world, prostate cancer is a large and growing problem. Without reductions in incidence or improvements in treatment, about 40 000 men in the United States will die annually from this malignancy by the year 2000 (1). The success in treating advanced prostate cancers remains poor, drawing attention to dietary factors that may influence risk of this malignancy, particularly animal fat, retinol, and carotenoids (2,3). Adequate levels of vitamin A or retinol are necessary for the normal control of both cellular differentiation and proliferation (4), and various retinoids have displayed the ability to inhibit carcinogenesis in animal models (5), including prostate cancer (6). However, in some experimental studies retinoids have enhanced carcinogenesis (7,8), and several human studies have found a direct association between retinol intake and risk of prostate cancer, particularly among men aged 70 years or older (9-13).

In contrast to dietary retinol, intake of β -carotene or provitamin A has been either inversely associated (14-16) or unassociated with risk of prostate cancer (2). In addition to being converted into vitamin A, β -carotene might influence carcinogenesis by reducing free radical damage (17) or by enhancing immunologic function (18,19). Although work has focused on β -carotene, more than 500 types of carotenoids exist in nature. The most common carotenoids include α -carotene, lycopene, lutein, and β -cryptoxanthin in addition to β -carotene. Epidemiologic data regarding specific carotenoids (other than β -carotene) and risk of prostate cancer are sparse because values for levels of carotenoids in foods have only recently become available (20). However, the study of food items or groups that

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