Orange Juice, a Marker of Diet Quality, Contributes to Essential Micronutrient and Antioxidant Intakes in the United States Population

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ABSTRACT

Objective: To evaluate the impact of 100% orange juice (OJ) on the healthy diet and micronutrient intakes of the United States population.

Methods: Cross-sectional study of 13,971 people in the United States aged ≥ 4 years using 2 24-hour diet recalls from the National Health and Nutrition Examination Survey, 2003-2006.

Results: Consumption of OJ was higher among 4- to 8-year-old children, older adults (> 50 y old), non-Hispanic blacks, those with lower body mass index, those of lower income level, nonsmokers, dietary supplement users, and those participating in regular exercise ($P < .05$). Consumption of OJ was positively associated with the percentage of participants meeting MyPyramid recommendations for fruit consumption. Increased OJ consumption was correlated with increased daily intakes of certain micronutrients and antioxidants ($P < .05$). Percentages of participants with intakes below Estimated Average Requirements for these micronutrients decreased with increased OJ consumption ($P < .001$).

Conclusions and Implications: The implicated nutritional and potential health benefits of OJ warrant further investigation in clinical research studies.

Key Words: orange juice, antioxidants, nutrient adequacy, fruit recommendation, National Health and Nutrition Examination Survey (*J Nutr Educ Behav*. 2013;45:340-348.)

INTRODUCTION

High consumption of fruits and vegetables has been associated with decreased incidence and mortality rate of various degenerative diseases such as cardiovascular disease and specific cancers.[1,2] Consequently, the Dietary Guidelines for Americans have included fruits and vegetables in the "Food Groups to Encourage" guideline,[3] and the United States Department of Agriculture (USDA) MyPlate recommends that half the plate consist of fruits and vegetables.[4] However, despite continuous effort by the United States (US) government and the World Health Organization, prior assessments of national and international data failed to demonstrate increases in fruit or vegetable consumption over the past 20 years.[5,6] A recent study based on food consumption data from the 2003-2004 National Health and Nutrition Examination Survey (NHANES) documented that few American adolescents or adults reported consuming the recommended amounts of fruit or vegetables.[7] Therefore, in addition to developing effective approaches, including educational campaigns with policy and environmental strategies, presenting alternative food items that are able to make up nutrient needs may be an effective dietary strategy.

The current recommendations encourage children to eat fruit, including frozen bars from 100% juice, and providing 100% juice in children's lunch boxes.[8] The inclusion of 100% juice in this food group suggests that 100% juice is an important nutrient source. Thus, how fruit juice contributes to nutrient adequacy deserves attention on its own, even if whole fruit is the preferred source. Some have reported that consumption of 100% juice can contribute to excess calories in the diet and thus lead to obesity in children.[9] However, several studies have shown that children and adolescents who regularly consume 100% juice have a lower body mass index,[10,11] and those children consume healthier diets overall compared to those who consume less juice.[10] These findings also support the importance of investigating the nutrient contribution of this food source.

Orange juice (OJ) is the most commonly consumed fruit juice in the US. It has high levels of valuable nutrients

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such as vitamin C, potassium, folate, niacin, riboflavin, and magnesium.[12] In addition, fortification with calcium and vitamin D has made OJ a potential good source of these 2 nutrients. Although OJ is a healthy and nutrient-dense beverage, information on the contribution of 100% OJ to compliance with MyPlate recommendations for fruit consumption and micronutrient adequacy is limited. Therefore, this study aimed to evaluate the impact of 100% OJ on the healthy diet and micronutrient intake status of the US population.

METHODS

Study Population

The NHANES is conducted by the National Center for Health Statistics to obtain nationally representative information on the health and nutritional status of the US population. Individuals aged 4 years and older in NHANES 2003-2004 and 2005-2006 and having reliable complete diet recall data were included in this study (n = 13,971).[13,14] Participants were subgrouped by sociodemographic and lifestyle variables including age, sex, ethnicity, poverty income ratios, alcohol consumption (ages ≥ 12 y), current smoking status (ages ≥ 12 y), and exercise levels. Written informed consent was obtained from all participants or proxies, and the survey protocol was approved by the Research Ethics Review Board of the National Center for Health Statistics.

Dietary Data Analyses

The dietary intake data were estimated from the average of 2 24-hour diet recalls conducted in the NHANES 2003-2004 and 2005-2006.[13,14] Food consumption data were coded using the USDA Food and Nutrient Database for Dietary Studies 3.0 to produce micronutrient intake values. A special vitamin D database (an addendum to the USDA Food and Nutrient Database for Dietary Studies 3.0) was developed for estimating vitamin D intake.[15] In the present study, 100% OJ included unsweetened 100% OJ and unsweetened 100% OJ fortified with calcium and vitamin D. Orange juice consumers were defined as the participants who reported consuming 100% OJ as a beverage at least once in the nonconsecutive 2-day 24-hour diet recalls, whereas nonconsumers were defined as the rest of the participants, including those who reported consuming OJ but not 100% OJ.

The USDA MyPyramid servings database was used for calculating fruit servings.[16] Mixed dishes were disaggregated to determine the quantities of individual food ingredient intake. MyPyramid, now MyPlate, provides recommendations for fruit consumption based on individual calorie needs as determined by an individual's age, sex, and physical activity level and includes specific recommendations in the number of servings of fruit.[4]

The estimation of flavonoid and proanthocyanidin intake has recently been described in detail.[17] The NHANES food consumption data were matched with the USDA flavonoid/proanthocyanidin databases. Daily individual flavonoid/proanthocyanidin intake from selected food items was determined by multiplying the content of the individual flavonoid/proanthocyanidin (mg/g food) by the daily consumption (g/d) of the selected food item. Estimated total intake of flavonoid/proanthocyanidin was the sum of individual flavonoid/proanthocyanidin intake from all food sources reported in the 24-hour diet recalls. In order to convert the intake data of individual antioxidant compounds to total antioxidant capacity values, the vitamin C equivalent of 43 antioxidant nutrients measured previously was applied.[17]

Adequacy of micronutrients was determined by comparing intakes from the non-consecutive 2-d diet recalls to the Estimated Average Requirement (EAR)[15] and Adequate Intake (AI)[18] from the Dietary Reference Intake values.[19] Estimated Average Requirement estimates the average daily nutrient intake level to meet the requirement of half the healthy individuals in a particular life stage and sex.[19-21] Adequate Intake is a recommended average daily nutrient intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group or groups of apparently healthy people that are assumed to be adequate; it is used when a Recommended Daily Amount cannot be determined.[19] Percentages of individuals below the EAR or AI were generated for calcium, vitamin D,[22] vitamin C, vitamin E,[23] thiamin, riboflavin, niacin, vitamin B_6, folate,[24] potassium, and vitamin K.[25,26] Dietary supplements, medications, and estimation of vitamin D obtained from sunlight were not included.

Statistical Analysis

All data analyses were carried out using Statistical Analysis Systems statistical software package (version 9.2, SAS Institute, Inc, Cary, NC, 2009) and the Survey Data Analysis for multi-stage sample designs professional software package (SUDDAN; release 8.0.2, Research Triangle Institute, Research Triangle Park, NC, 2003). The SUDDAN software was used to increase the accuracy and validity of the results through computing variance estimates and test statistics for a stratified, multistage probability survey design. Weights provided in NHANES were used to account for the complex survey design (including oversampling), survey nonresponse, and post-stratification.[14]

The variables of dietary nutrients were found to be normally distributed through residual and goodness-of-fit analysis or quantile-quantile plot. Weighted arithmetic means of micronutrient intake of subpopulations grouped by sociodemographic and lifestyle variables were determined. Standard error was calculated by the linearization (Taylor series) variance estimation method for population parameters. The chi-square test was applied for assessing the distributions of categorical variables after excluding missing values in each categorical variable. The linear trends of micronutrient intake, food servings, percentage of participants meeting recommendations for fruits and vegetables, antioxidant intake, and percentage of micronutrient intake below the EAR among OJ nonconsumers and tertiles of consumers were tested using linear contrasts after adjustment for age, sex, ethnicity, and total energy intake. Values in the text are means ± standard error, all P values reported were 2-tailed, and statistical significance was defined as $P < .05$.

RESULTS

Twenty-five percent of all participants aged ≥ 4 years consumed 100% OJ on