ORIGINAL ARTICLE

Consumption of grapefruit is associated with higher nutrient intakes and diet quality among adults, and more favorable anthropometrics in women, NHANES 2003–2008

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Abstract

Background: Dietary guidance recommends consumption of a nutrient-dense diet containing a variety of fruits. The purpose of this study was to estimate usual nutrient intakes and adequacy of nutrient intakes among adult grapefruit consumers and non-consumers, and to examine associations between grapefruit consumption and select health parameters.

Methods: The analysis was conducted with data collected in the National Health and Nutrition Examination Survey (NHANES) 2003–2008. Respondents reporting consumption of any amount of grapefruit or 100% grapefruit juice at least once during the 2 days of dietary recall were classified as grapefruit consumers.

Results: Among adults aged 19+ years with 2 days of dietary recall ($n = 12,789$), 2.5% of males and 2.7% of females reported consumption of 100% grapefruit juice or fresh, canned, or frozen grapefruit during the recalls. Grapefruit consumers were less likely to have usual intakes of vitamin C (males: 0% vs. 47%; females: 0% vs. 43%; $P < 0.001$) and magnesium ($P < 0.05$) below the estimated average requirement (EAR) compared to non-consumers, and they were more likely to meet adequate intake levels for dietary fiber ($P < 0.05$). Potassium and β-carotene intakes were significantly higher among grapefruit consumers ($P < 0.001$). Diet quality as assessed by the Healthy Eating Index-2005 (HEI-2005) was higher in grapefruit consumers (males: 66.2 [95% CI: 61.0–71.5] vs. 55.4 [95% CI: 54.4–56.4]; females: 71.4 [95% CI: 65.1–77.6] vs. 61.2 [95% CI: 59.8–62.6]). Among women, grapefruit consumption was associated with lower body weight, waist circumference, body mass index (BMI), triglycerides, C-reactive protein (CRP), and higher high-density lipoprotein (HDL) cholesterol ($P < 0.05$), However, risk of being overweight/obese was not associated with grapefruit consumption.

Conclusion: Consumption of grapefruit was associated with higher intakes of vitamin C, magnesium, potassium, dietary fiber, and improved diet quality. Grapefruit may provide a healthful option for adults striving to meet fruit recommendations.

Keywords: *grapefruit*; *juice*; *citrus*; *nutrient intake*; *adults*; *NHANES*; *anthropometrics*; *body weight*; *BMI*

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The Dietary Guidelines for Americans encourage consumption of a nutrient-dense diet rich in fruits and vegetables (1), though most Americans fall short of meeting the recommended levels of fruit intake (2). Among both men and women, the top five contributors to total fruit consumption are 100% orange juice, bananas, apples, oranges, and watermelon; collectively, these five items account for 53 and 46% of total fruit intake by men and women, respectively (3).

Like oranges and 100% orange juice, grapefruit and 100% grapefruit juice are also citrus fruits that are particularly concentrated sources of vitamin C and a source of other nutrients. Reference data for labeling purposes (4) indicate that a serving of pink or red grapefruit, corresponding to ½ of a medium fruit (154 g), provides 100% of the Daily Value (DV) of vitamin C, 35% of the DV for vitamin A, 8% of the DV for fiber, 5% of the DV for potassium, and less than 5% of the DV for folate, calcium,

magnesium, vitamin B_6, thiamin, and niacin (5). Pink and white grapefruit juice and orange juice were found to have more favorable nutrient density scores compared with other commonly consumed 100% fruit juices, including apple, grape, pineapple, and prune (6). Similarly, fresh grapefruit (white and pink) tended to have higher nutrient density scores when compared to some commonly consumed fresh fruit such as apples, bananas, and peaches (7).

In addition to vitamins and minerals, citrus fruits also contain several phytonutrients. Grapefruit, particularly pink and red varieties, provide the carotenoids β-carotene and lycopene (8). Grapefruit also provides naringin, a flavonoid in the flavanone subclass (9) that may have cardiovascular benefits (10). In animal studies, naringin has been reported to have beneficial effects on neuroinflammation (11), blood lipids (12), and bone mineral content (13).

Findings from observational studies suggest an association between grapefruit consumption and reduced risk for coronary heart disease mortality (14), and between citrus consumption and decreased acute coronary events (15) or ischemic stroke (16).

Food consumption data collected in the mid-1990s showed that grapefruit juice and grapefruit, including grapefruit in fruit salads, were consumed by approximately 7% of the US population aged 2 years and older at least once in 2 days of dietary recall (17). Little is known about recent consumption of grapefruit by adults, nutrient intakes by consumers of this fruit, and potential associations between consumption of grapefruit and select health parameters. The purpose of this study was to identify patterns of grapefruit (whole fruit and juice) consumption among adults in the United States, and associations between consumption and select indicators of nutrition and health.

Methods

Data source and study population
Data collected as part of the National Health and Nutrition Examination Surveys (NHANES) conducted in the combined periods 2003–2004, 2005–2006, and 2007–2008 were used to complete this cross-sectional study. NHANES is designed to provide nationally representative nutrition and health data and prevalence estimates for nutrition and health status measures in the United States. Approval for the NHANES data collection was provided by the National Center for Health Statistics (NCHS) Research Ethics Review Board. The sample for this analysis was limited to males and non-pregnant, non-lactating females aged 19 years and older ($n = 12,789$).

Dietary intake data
Information on food consumption was collected via two 24-h dietary recalls in the dietary interview component

of NHANES, also known as What We Eat in America (WWEIA; 18–20). Trained dietary interviewers collected detailed information on all foods and beverages consumed by respondents in the preceding 24-h time period (midnight to midnight); recalls may have covered any day of the week, including weekends. A second dietary recall was administered by telephone 3 to 10 days after the first dietary interview, but not on the same day of the week as the first interview. Only adults who provided two complete and reliable dietary recalls meeting criteria for completeness as determined by the NCHS were included in the study population (18–20).

Identification of grapefruit consumers
In this analysis, respondents were classified as grapefruit consumers if they reported consumption of any amount of 100% grapefruit juice or fresh, canned, or frozen grapefruit, including 'grapefruit & orange sections', at least once during the 2 days of dietary recall. Individuals reporting intake of a fruit salad that may have contained grapefruit or a juice drink blend containing grapefruit juice were not considered to be grapefruit consumers. None of the food codes representing 100% grapefruit juice or 100% fresh, canned, or frozen grapefruit identified the type of grapefruit by color (i.e. white, pink, or red).

Nutrient intake data
The United States Department of Agriculture (USDA) processes food consumption data collected during each WWEIA cycle using the most up-to-date food composition values available at the time. Nutrient intakes for NHANES 2007–2008 were processed using USDA's Food and Nutrient Database for Dietary Studies, 4.1 (FNDDS 4.1), intakes from 2005–2006 were processed using FNDDS 3.0, and intakes from 2003–2004 were processed using FNDDS 2.0 (21–23). The USDA data files indicate that nutrient values for raw grapefruit represented an unspecified mixture of white, pink, and red varieties, and nutrient values for grapefruit juice represented nutrient concentration data for white grapefruit juice (21–23). Nutrient intakes assessed included energy, protein, carbohydrate, total sugars, dietary fiber, total and saturated fat, cholesterol, and key nutrients in grapefruit, including vitamin A, β-carotene, lycopene, vitamin B_6, folate, vitamin C, calcium, magnesium, and potassium.

Healthy Eating Index-2005 and food group equivalents
Healthy Eating Index-2005 (HEI-2005) scores, a measure of overall diet quality (24), and intakes of food groups (excluding grapefruit) were calculated using food group equivalent intake data as provided by the USDA (25, 26).

Anthropometric data
During the examination component of NHANES, participants underwent a physical examination that included measurement of height, weight, and waist circumference

using standardized data collection methods (27–29). Body mass index (BMI, kg/m^2) was calculated as weight (kg) divided by height (m) squared. Individuals were categorized as being of healthy (or underweight) bodyweight status or as being of overweight/obese bodyweight status based on criteria from the Centers for Disease Control and Prevention (CDC).

Physiologic parameter data

The physical examination component also included collection of blood pressure measurements and blood samples for laboratory analyses (27–29). Repeated blood pressure measurements (up to three measurements each of systolic and diastolic blood pressure) were collected from each participant after resting quietly in a sitting position for 5 min. Blood samples were collected via standardized procedures for assessment of numerous analytes (30–32), including serum total cholesterol and serum high-density lipoprotein (HDL) cholesterol in blood samples from non-fasting subjects. A subset of survey participants provided fasting blood samples, which were analyzed for triglycerides, plasma glucose, and serum insulin. The NHANES data files provide low-density lipoprotein (LDL) cholesterol levels for participants with fasting blood samples derived from measured values of total cholesterol, triglycerides, and HDL cholesterol according to the Friedewald calculation: [LDL cholesterol] = [total cholesterol] − [HDL cholesterol] − [triglycerides/5]. Additional measures in blood samples from non-fasting subjects included C-reactive protein (CRP) and red blood cell (RBC) folate levels; during NHANES 2003–2006, blood samples also were analyzed for serum vitamin A (retinol) and β-carotene (*trans* and *cis* forms), and serum vitamin C.

Demographics and other participant characteristics

Demographic information and other characteristics including physical activity were used as covariates in analyses of some parameters in the current study. Demographic characteristics including age, sex, race (categorized as non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, or other), and education level (categorized as less than high school graduate, high school graduate/GED or equivalent, or beyond high school) were self-reported by participants (33–35). Physical activity information was collected as part of the in-home questionnaire (36–38); the survey included questions about participation in vigorous or moderate physical activity for at least 10 min during the previous 30 days in 2003–2004 and 2005–2006 or during the previous week in 2007–2008. Based on the approach recently reported by Zhang and colleagues (39), we categorized participants as physically inactive if they reported no engagement in at least 10 min of moderate or vigorous activity.

Statistical analyses

Adults were classified as consumers or non-consumers of grapefruit based on reported food intakes and the definition of grapefruit consumers in this analysis. Among the population of grapefruit consumers, the proportion of consumers by form of grapefruit (fresh, canned/frozen, or juice) and usual intakes were estimated.

Usual total nutrient intakes, excluding nutrient intakes from dietary supplements, were estimated for the populations of grapefruit consumers and non-consumers. Usual nutrient intake estimates were generated using Software for Intake Distribution Estimation (C-SIDE, version 1.02, 1997, Department of Statistics, Iowa State University), which accounted for inter- and intra-individual variations in intake (40, 41). The percentage of a population with usual nutrient intakes below life-stage-specific estimated average requirements (EAR) provides a measure of inadequate intakes, while a mean usual intake at or above life-stage-specific adequate intake (AI) levels implies a low prevalence of inadequate intakes (42). Percentages of each population with usual intakes below the EAR were calculated for vitamin A, vitamin B_6, folate, vitamin C, calcium, and magnesium using the cut-point method (42). For potassium and dietary fiber, nutrients for which EARs were not established, the percentages of adults with usual intakes at or above the AI were estimated.

HEI scores were calculated for populations of adult grapefruit consumers and non-consumers using the HEI-2005 scoring standards and analytical support files provided by the CNPP (24, 43). Estimates of 2-day average food group equivalents were calculated from all foods reported consumed other than grapefruit.

Anthropometric measures including weight, waist circumference, and BMI and the odds ratio of grapefruit consumers being overweight or obese (BMI ≥ 25.0) using a logistic regression were estimated for the subpopulations of grapefruit consumers and non-consumers with adjustments for age, sex, race/ethnicity, education, and physical activity.

Mean levels of physiologic measures including systolic and diastolic blood pressure, serum total, HDL and LDL cholesterol, serum triglycerides, plasma glucose, serum insulin, CRP, serum vitamin C, serum vitamin A (retinol), serum β-carotene (*cis* and *trans* forms), and RBC folate were estimated for each subpopulation of grapefruit consumers and non-consumers. All estimates of physiologic measures were adjusted for age, sex, race/ethnicity, and education.

Comparisons of usual nutrient intakes, percentages below the EAR or above the AI, and mean anthropometric and physiologic parameters between populations of grapefruit consumers and non-consumers were conducted using STATA statistical software package version 10 (Stata-Corp, College Station, TX, USA). All summary statistics and analyses were adjusted for the complex survey design of

NHANES with statistical weights provided by the NCHS. Statistical differences were considered significant at $P < 0.05$.

All analyses were completed for males, females, and all adults (males and females combined). For findings for the combined population of males and females, see Supplementary file with results for adults 19+ years.

Results

Characteristics of grapefruit consumers and non-consumers and mean intakes of grapefruit among consumers

Using the definition of a grapefruit consumer in this analysis, 333 survey respondents aged 19 years and older, representing 2.5% of males and 2.7% of females, were classified as grapefruit consumers (Table 1). Among both males and females, consumers of grapefruit were older and more likely to have an education beyond high school than non-consumers ($P < 0.005$). The percentage of males across race/ethnicity categories differed between consumers and non-consumers of grapefruit ($P = 0.041$). Among males and females, the percentage of adults identified as physically inactive did not differ between consumers and non-consumers of grapefruit. The estimated usual intake of grapefruit was 162 g/day among male consumers of grapefruit and 151 g/day among female consumers. As shown in Fig. 1, male grapefruit consumers were most likely to consume grapefruit in the form of juice, while female consumers of grapefruit were most likely to consume fresh grapefruit.

Nutrition intakes, adequacy of intake, and diet quality among grapefruit consumers and non-consumers

Usual intakes of energy and select nutrients from the total diet were estimated for the populations of grapefruit consumers and non-consumers (Table 2). Energy intakes did not differ between grapefruit consumers and non-consumers. Male and female grapefruit consumers had higher usual intakes of dietary fiber than non-consumers, while total fat, saturated fat, and cholesterol intakes by female grapefruit consumers were lower than intakes by non-consumers. Usual intakes of β-carotene, vitamin C, magnesium, and potassium were higher among both male and female grapefruit consumers than non-consumers. Male grapefruit consumers had significantly higher usual intakes of vitamin A than non-consumers, and vitamin B_6 intakes by female grapefruit consumers were higher than intakes by non-consumers.

Adequacy of nutrient intakes is shown in Figs. 2 and 3. Grapefruit consumers were less likely to have usual intakes of vitamin C or magnesium below the EAR, and female grapefruit consumers were less likely to have intakes of vitamins A and B_6 below the EAR compared to grapefruit non-consumers (Fig. 2). A higher percentage of grapefruit consumers had intakes of dietary fiber above the AI compared to non-consumers (Fig. 3).

Compared to non-consumers of grapefruit, male and female grapefruit consumers had higher intakes of whole grains and total fruit including 100% fruit juice (other than grapefruit or grapefruit juice), and lower intakes of added sugars ($P < 0.05$) (Table 3). Male consumers of grapefruit

Table 1. Demographics of male and female grapefruit consumers and non-consumers aged 19+ years, NHANES 2003–2008

	Males					Females				
	Grapefruit consumers[a] ($n = 153$)		Grapefruit non-consumers ($n = 6,237$)			Grapefruit consumers[a] ($n = 180$)		Grapefruit non-consumers ($n = 6,219$)		
Demographics	Mean	SE	Mean	SE	P	Mean	SE	Mean	SE	P
Age (years)	52.9	1.64	45.4	0.44	<0.001	53.8	2.11	47.6	0.38	0.004
Education (%)					0.003					<0.001
Less than high school	10	2.4	18	1.0		19	3.3	18	0.9	
High school	18	3.8	26	1.1		10	2.7	26	0.9	
More than high school	72	3.8	56	1.5		72	3.9	56	1.4	
Race/ethnicity (%)					0.041					0.371
Non-Hispanic White	85	3.6	72	1.9		70	4.5	73	2.1	
Non-Hispanic Black	9	2.5	11	1.0		13	3.1	12	1.3	
Mexican American	3	1.4	9	1.0		5	2.0	7	0.8	
Other Hispanic	1	0.6	3	0.5		5	1.8	4	0.5	
Other race	2	1.9	5	0.5		8	3.9	4	0.5	
Physically inactive (%)	30	5.0	36	1.4	0.293	32	5.0	40	1.3	0.140

[a]Grapefruit consumers reported consumption of 100% grapefruit juice or 100% fresh, canned, or frozen grapefruit at least once on the 2 days of dietary recall.
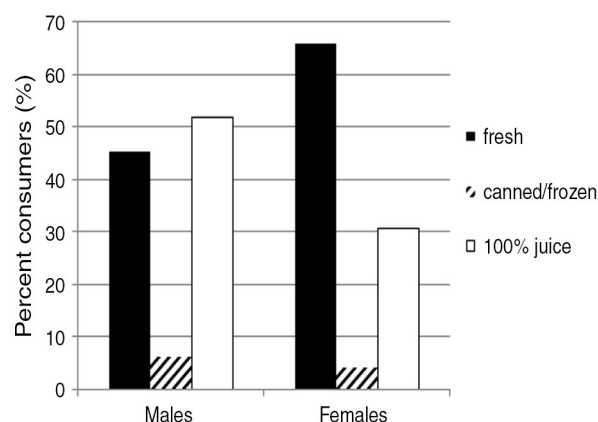
Fig. 1. Proportion of male and female grapefruit consumers aged 19+ years by form of grapefruit consumed, NHANES 2003–2008. Grapefruit consumers reported consumption of 100% grapefruit juice or 100% fresh, canned, or frozen grapefruit at least once on the 2 days of dietary recall. Some adults reported consumption of more than one form of grapefruit; the sum of percent consumers by type therefore is greater than 100. All estimates were generated with statistical weights provided by the National Center for Health Statistics (NCHS).

reported eating more vegetables and less poultry compared to non-consumers of grapefruit, while female consumers of grapefruit had lower intakes of meats and solid fat than non-consumers (Table 3). Among both males and females, grapefruit consumers had significantly higher HEI-2005 scores than non-consumers. Mean HEI-2005 scores for male grapefruit consumers and non-consumers were 66.2 [95% confidence interval (CI): 61.0–71.5] and 55.4 [95% CI: 54.4–56.4], respectively; scores for female grapefruit consumers and non-consumers were 71.4 (95% CI: 65.1–77.6) and 61.2 (95% CI: 59.8–62.6), respectively.

Anthropometric measures of grapefruit consumers and non-consumers

Mean anthropometric measures of grapefruit consumers and non-consumers are shown in Table 4. The anthropometric measures including body weight, waist circumference and BMI were lower among female grapefruit consumers as compared to grapefruit non-consumers. There were no significant differences in risk of being overweight or obese (BMI ≥ 25.0) between grapefruit consumers and non-consumers (males: OR $= 0.64$ [95% CI: 0.35–1.17,

Table 2. Usual dietary intake of select nutrients by male and female grapefruit consumers and non-consumers aged 19+ years, NHANES 2003–2008
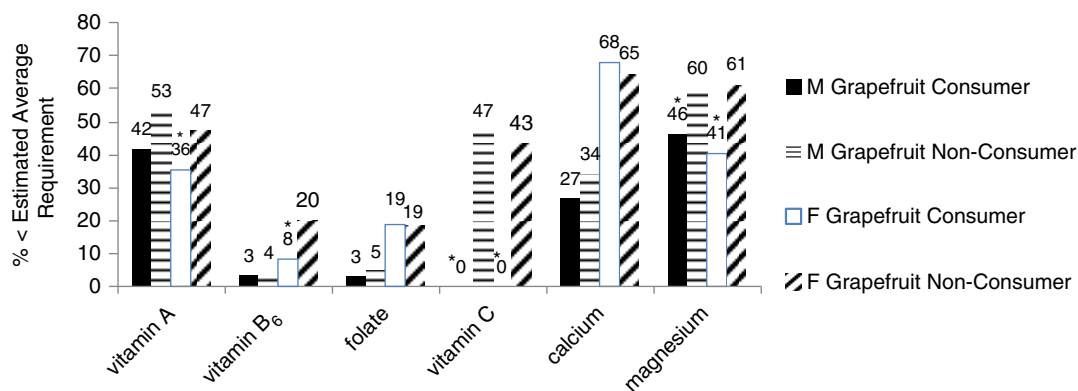
Nutrient[b]	Males					Females				
	Grapefruit consumers[a] (n = 153)		Grapefruit non-consumers (n = 6,237)			Grapefruit consumers[a] (n = 180)		Grapefruit non-consumers (n = 6,219)		
	Mean	SE	Mean	SE	P	Mean	SE	Mean	SE	P
Energy (kcal)	2,591	83.5	2,584	14.6	0.933	1,734	34.5	1,789	8.4	0.139
Protein (g)	98	3.57	99.7	0.57	0.714	69.3	1.64	67.8	0.39	0.393
Carbohydrate (g)	308	8.1	306	1.8	0.825	221	5.7	221	1.2	0.986
Total sugars (g)	146	4.3	140	1.3	0.209	105	3.6	103	0.9	0.622
Dietary fiber (g)	21.9	1.02	17.5	0.19	<0.001	17.1	0.60	13.9	0.17	<0.001
Total fat (g)	98.2	3.99	98.0	0.70	0.960	63.2	1.83	69.1	0.46	0.005
Saturated fat (g)	30.8	1.48	32.6	0.24	0.240	19.8	0.67	22.9	0.16	<0.001
Cholesterol (mg)	368	27.2	355	2.5	0.650	208	7.3	230	1.5	0.003
Vitamin A (mcg RAE)	906	77.5	664	7.8	0.003	596	20.2	570	6.7	0.189
β-carotene (mcg)	3,025	162.6	1,935	34.9	<0.001	3,259	196.2	1,926	43.9	<0.001
Lycopene (mcg)[c]	8,675	1440.1	6,860	171.9	0.203	5,145	692.2	4,924	148.6	0.759
Vitamin B$_6$ (mg)	2.38	0.076	2.32	0.017	0.518	1.79	0.056	1.62	0.014	0.004
Folate (mcg DFE)	635	21.6	619	5.0	0.430	478	20.5	464	4.7	0.527
Vitamin C (mg)	187.0	7.97	91.5	1.33	<0.001	145.1	3.86	75.6	1.24	<0.001
Calcium (mg)	1,038	36.2	1,036	9.5	0.945	831	27.0	812	7.7	0.465
Magnesium (mg)	381	10.6	333	2.7	<0.001	286	9.3	252	2.6	0.001
Potassium (mg)	3,590	58.4	3,087	20.2	<0.001	2,680	52.1	2,314	17.2	<0.001

[a]Grapefruit consumers reported consumption of 100% grapefruit juice or 100% fresh, canned, or frozen grapefruit at least once on the 2 days of dietary recall.

[b]Usual intakes estimated using C-Side (Department of Statistics, Iowa State University). All estimates were generated with statistical weights provided by the National Center for Health Statistics (NCHS).

[c]Estimates represent 2-day average intakes.

Fig. 2. Percent of male and female grapefruit consumers and non-consumers aged 19+ years with usual nutrient intakes below the estimated average requirement (EAR), NHANES 2003–2008. *$P < 0.05$ consumer vs. non-consumer.

$P = 0.14$]; females: OR = 0.64 [95% CI: 0.36–1.13, $P = 0.118$]; OR = odds ratio; data not shown).

### Physiologic parameters of grapefruit consumers and non-consumers

Mean levels of select physiologic measures among grapefruit consumers and non-consumers also are shown in Table 4. Among adult females, HDL cholesterol was significantly higher among grapefruit consumers compared to non-consumers, and female grapefruit consumers had significantly lower triglyceride and CRP levels than non-consumers. Male grapefruit consumers had significantly higher levels of vitamins C and β-carotene (*cis* and *trans* forms) and significantly lower RBC folate levels than non-consumers.

Discussion

This was the first study to our knowledge to assess grapefruit intake and associations with nutrient intake and nutrient intake adequacy, diet quality, and health parameters in a nationally representative sample of adults. Results from this assessment show that grapefruit is consumed by a relatively small fraction of adults, as slightly fewer than 3% of adults reported consumption of either 100% grapefruit juice or 100% fresh, canned, or frozen

grapefruit at least once on 2 days of dietary recall. Among the adults who did report consumption of grapefruit, findings from this cross-sectional study suggest that grapefruit consumption was associated with some positive shifts in nutrient intake, nutrient intake adequacy, and diet quality as measured by the HEI-2005.

The Dietary Guidelines identify, among others, magnesium and vitamins A and C as under-consumed nutrients, and potassium and dietary fiber as nutrients of public concern (1). Mean intakes of magnesium, vitamin C, and potassium were higher among grapefruit consumers than non-consumers. A lower percentage of grapefruit consumers versus non-consumers had intakes of magnesium and vitamin C below the EAR, and grapefruit consumers in this study were more likely to have fiber intakes above the AI level. Grapefruit consumers also had higher intakes of potassium than non-consumers, though the increased intake did not result in a greater proportion of adults meeting recommended potassium intakes. In addition to increased intakes of nutrients to encourage, grapefruit consumers had lower intakes compared to non-consumers of components to limit, namely added sugars (men and women) and saturated fat (women only). Overall, diet quality was higher among grapefruit consumers than non-consumers, including higher intake of fruits other than
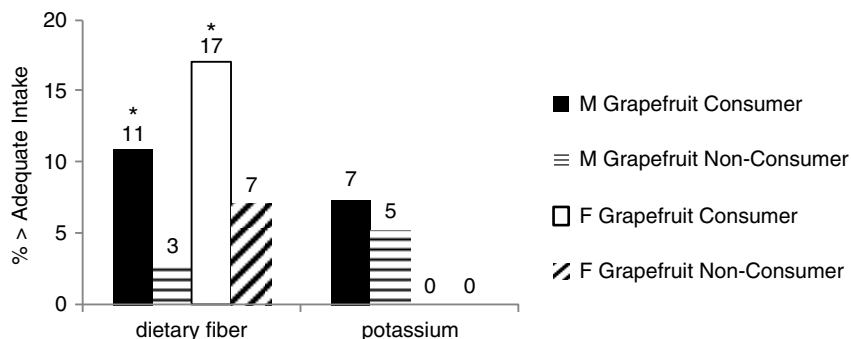
Fig. 3. Percent of male and female grapefruit consumers and non-consumers aged 19+ years with usual nutrient intakes above the adequate intake (AI), NHANES 2003–2008. $P < 0.05$ consumer vs. non-consumer.

Table 3. Two-day average intake of food components from foods other than grapefruit by male and female grapefruit consumers and non-consumers aged 19+ years, NHANES 2003–2008

Food component	Males					Females				
	Grapefruit consumers[a] (n = 153)		Grapefruit non-consumers (n = 6,237)			Grapefruit consumers[a] (n = 180)		Grapefruit non-consumers (n = 6,219)		
	Mean	SE	Mean	SE	P	Mean	SE	Mean	SE	P
Total fruit (cup eq/day)	1.6	0.14	1.0	0.03	<0.001	1.3	0.08	1.0	0.03	<0.001
Total vegetables (cup eq/day)	2.1	0.11	1.8	0.02	0.026	1.7	0.11	1.5	0.02	0.097
Total grains (ounce eq/day)	7.4	0.36	7.8	0.07	0.210	5.2	0.23	5.6	0.05	0.138
Whole grains (ounce eq/day)	1.3	0.26	0.8	0.03	0.031	0.9	0.12	0.7	0.03	0.039
Total dairy (cup eq/day)	1.6	0.11	1.7	0.04	0.101	1.3	0.09	1.4	0.03	0.357
Meat/franks (ounce eq/day)	3.6	0.47	3.7	0.07	0.877	1.4	0.14	2.1	0.04	<0.001
Poultry (ounce eq/day)	1.2	0.15	1.7	0.05	0.003	1.5	0.16	1.3	0.04	0.097
Total fish (ounce eq/day)	1.1	0.26	0.7	0.04	0.158	0.9	0.20	0.5	0.03	0.080
Eggs (ounce eq/day)	0.7	0.10	0.6	0.01	0.298	0.4	0.04	0.4	0.01	0.982
Nuts/seeds/soy/legumes (ounce eq/day)	1.2	0.27	0.9	0.04	0.274	1.0	0.22	0.7	0.03	0.172
Discretionary oil (g/day)	23.5	1.94	21.3	0.39	0.237	15.4	1.45	16.6	0.22	0.414
Discretionary solid fat (g/day)	48.4	3.00	53.0	0.57	0.132	30.9	1.77	37.1	0.44	0.002
Added sugars (teaspoon/day)	17.0	1.21	21.3	0.40	0.002	12.3	0.87	15.0	0.29	0.008

[a]Grapefruit consumers reported consumption of 100% grapefruit juice or 100% fresh, canned, or frozen grapefruit at least once on the 2 days of dietary recall.

grapefruit. Similar findings were reported in a recent cross-sectional study of nutrient intakes by adult consumers of 100% orange juice; in that study, usual intakes of total fruit, whole grains, folate, magnesium, potassium, fiber, and vitamins A, B_6, and C were higher among consumers of orange juice compared to non-consumers (44).

In processing the WWEIA food intake records, USDA assumed that the nutrient composition of fresh grapefruit consumed by the US population reflects a combination of nutrient concentrations in white, pink, and red fruit, with each 100 g of fruit providing an average of 1,419 mcg lycopene, 686 mcg β-carotene, and 58 mcg vitamin A (45). In contrast, the nutrient composition data of grapefruit juice used by USDA was based exclusively on the nutrient profile of white grapefruit juice and contains no lycopene, 14 mcg β-carotene, and 2 mcg vitamin A (46). Pink or red grapefruit juice accounted for well over half of total annual retail sales of grapefruit juice since 2004 (Florida Department of Citrus, personal communication), therefore estimates of carotenoid and vitamin A intakes by consumers of grapefruit juice are likely underestimated.

Differences in anthropometric measures and physiologic measures were observed between some adult populations of grapefruit consumers and non-consumers. Female grapefruit consumers had a lower mean body weight, waist circumference, and BMI than non-consumers. These differences in anthropometric measures were not observed among males. Findings from a preliminary intervention

study in 91 obese men and women reported that consumption of half of a fresh grapefruit before meals for 12 weeks resulted in significant weight loss and improved insulin resistance among participating adults with metabolic syndrome (47). In a randomized controlled trial of overweight men and women who consumed ½ of a ruby red grapefruit before each of three daily meals for 6 weeks (n = 39, mean age 39.4 years), no effects on body weight or anthropometric measures when compared to a control condition (no grapefruit, n = 32, mean age 44.0 years) were reported (48). However, when compared with baseline values, significant decreases in waist circumference and waist-to-hip ratio were demonstrated in grapefruit consumers. These data suggest that fresh grapefruit or grapefruit juice may not independently affect weight or body composition parameters but when included as part of a reduced calorie diet may provide additional nutritional and health benefits.

Significantly higher levels of HDL cholesterol were observed in the subpopulation of female grapefruit consumers compared to non-consumers. Clinical studies report similar effects of grapefruit on HDL cholesterol. In a study of 85 obese men and women, consumption of 127 g of grapefruit juice daily for 12 weeks as a preload to each of three main meals was associated with a mean HDL cholesterol increase of 4.9±7.5 mg/dL versus a decrease of 2.0±7.2 mg/dL in participants consuming a water preload (P = 0.017); HDL cholesterol also increased by

Table 4. Anthropometric and physiologic measures of male and female grapefruit consumers and non-consumers aged 19+ years, NHANES 2003–2008

	Males							Females						
	Grapefruit consumers[a]			Grapefruit non-consumers				Grapefruit consumers[a]			Grapefruit non-consumers			
Parameter[b]	n	Mean	SE	n	Mean	SE	P	n	Mean	SE	n	Mean	SE	P
Weight (kg)	151	85.8	2.07	6,162	88.4	0.39	0.219	180	70.9	1.63	6,120	75.4	0.49	0.008
WC (cm)	148	101.5	1.62	6,013	103.0	0.28	0.346	171	90.5	1.29	5,962	94.8	0.40	0.001
BMI (kg/m^2)	151	27.9	0.61	6,144	28.7	0.12	0.227	180	27.0	0.57	6,104	28.6	0.18	0.007
SBP (mm Hg)	143	122	1.6	6,039	124	0.4	0.093	175	122	1.8	5,935	122	0.3	0.957
DBP (mm Hg)	141	72	0.9	6,015	72	0.3	0.619	169	72	1.3	5,894	70	0.3	0.158
Total-C (mmol/L)	148	5.12	0.093	5,974	5.09	0.020	0.744	170	5.23	0.085	5,891	5.20	0.022	0.733
HDL-C (mmol/L)	148	1.26	0.042	5,974	1.23	0.007	0.435	170	1.64	0.047	5,890	1.51	0.008	0.009
LDL-C (mmol/L)[c]	57	2.92	0.121	2,600	3.00	0.019	0.497	81	2.85	0.109	2,580	2.98	0.023	0.258
Triglyceride (mmol/L)[c]	59	1.59	0.211	2,687	1.72	0.032	0.560	82	1.19	0.065	2,615	1.46	0.028	0.001
Glucose (mmol/L)[c]	59	5.66	0.229	2,699	5.88	0.038	0.357	82	5.59	0.156	2,642	5.62	0.036	0.864
Insulin (pmol/L)[c]	59	59	7.2	2,679	71	1.6	0.107	81	57	5.6	2,596	64	1.5	0.266
CRP (mg/dL)	148	0.55	0.200	5,975	0.35	0.017	0.311	170	0.35	0.053	5,914	0.50	0.021	0.011
Vitamin C (umol/L)[d]	97	56	2.9	3,796	50	0.9	0.023	98	68	4.9	3,655	58	1.0	0.079
Vitamin A (retinol, umol/L)[d]	98	2.3	0.09	3,804	2.2	0.01	0.270	98	2.1	0.09	3,658	2.0	0.01	0.123
trans-β-carotene (umol/L)[d]	98	0.40	0.045	3,804	0.27	0.006	0.005	98	0.60	0.121	3,658	0.39	0.015	0.092
cis-β-carotene (umol/L)[d]	90	0.03	0.003	3,627	0.02	0.000	0.023	95	0.04	0.008	3,516	0.03	0.001	0.111
Folate, RBC (nmol/L)	147	733	44.3	5,961	830	16.3	0.021	171	932	68.0	5,927	891	18.5	0.576

[a]Grapefruit consumers reported consumption of 100% grapefruit juice or 100% fresh, canned, or frozen grapefruit at least once on the 2 days of dietary recall.

[b]Estimates adjusted for age, sex, race/ethnicity, and education; weight, WC, and BMI also adjusted for physical activity. Estimates based on small sample sizes may be less statistically reliable. All estimates were generated with statistical weights provided by the National Center for Health Statistics (NCHS).

[c]Limited to individuals with a fasting blood sample.

[d]Parameter assessed only in NHANES 2003–2006 (males: 100 grapefruit consumers and 3,984 non-consumers; females: 104 grapefruit consumers and 3,884 non-consumers).

BMI = body mass index; CRP = C-reactive protein; DBP = diastolic blood pressure; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; RBC = red blood cell; SBP = systolic blood pressure; total-C = total cholesterol; WC = waist circumference.

3.0 ± 5.2 mg/dL in subjects consuming a fresh grapefruit preload though the change was not significantly different from the water preload group (49). Female grapefruit consumers also had decreased levels of triglycerides and CRP compared to non-consumers of grapefruit. Lower serum triglycerides have been observed in a clinical trial with 57 hyperlipidemic men and women aged between 39 and 72 years consuming a heart-healthy diet including one fresh red grapefruit daily for 30 days (50). The lower CRP levels in female grapefruit consumers observed in our study is consistent with data from the Nurses' Health Study where the consumption of at least one serving per day of grapefruit (including 100% grapefruit juice) was associated with significantly lower CRP concentrations compared to intake of less than one serving per month (51). The lower blood folate levels observed in male grapefruit consumers compared to non-consumers may have been related to other food choices in the diet, as grapefruit and grapefruit juice provide modest levels of folate

(6% of the DV for eight ounces of grapefruit juice and 4% of the DV for ½ of a medium fresh grapefruit). Although several intervention trials have reported beneficial effects on blood pressure with consumption of fresh grapefruit by normotensive overweight men and women (48), grapefruit juice by normotensive and hypertensive men and women (52), or high flavonoid grapefruit–pummelo hybrid 'sweetie' fruit juice by men and women with Stage I hypertension (53), grapefruit consumption as such was not associated with lower blood pressure in the current observational study. We also did not observe an association between grapefruit consumption and LDL or total cholesterol. Clinical studies have reported significantly lower LDL or total cholesterol concentrations in adults consuming fresh grapefruit who did not have high cholesterol (defined as ≥ 225 mg/dL) (48), who were hyperlipidemic (50), or hypercholesterolemic men and women who consumed 'sweetie' juice (54). In our NHANES analysis, it is unknown whether there were

beneficial associations between grapefruit consumption and blood pressure or blood lipids in individuals with elevated levels since the data were not stratified by blood pressure or blood lipid status.

Diet quality was higher among consumers of grapefruit, which could impact the observed associations between grapefruit consumers and anthropometric and physiologic measures. In order to account for the potential effect of differences in diet quality, analyses of anthropometric and physiologic measures were repeated with an adjustment for each food group with statistically significant differences between grapefruit consumers and non-consumers (fruit excluding grapefruit, whole grains, vegetables, dairy, meat/franks, poultry, fish, discretionary solid fat, added sugars). The adjustment for food group intakes did not affect the significant associations observed between grapefruit consumption and anthropometric and physiologic parameters in women, while the few associations observed among men were largely unchanged with the adjustment; hence, our overall conclusions did not change. Differences in food group intakes between grapefruit consumers and non-consumers could also affect differences in usual nutrient intakes though we did not examine this issue.

There are several strengths to this analysis, including a large, nationally representative sample and calculation of usual nutrient intakes that are more representative of day-to-day intakes than intakes based on a single day of recall. As with all dietary surveys, however, the accuracy of the intake estimates is limited by the accuracy of recalls provided by survey participants. An additional limitation of this study is that grapefruit consumption was identified based on just 2 days of dietary recall. Adults who occasionally consume grapefruit but did not consume the fruit or juice during the recalls were classified as non-consumers in this assessment, and thus the estimated percentage of adults consuming grapefruit is likely underestimated. The analysis also is limited by the small number of NHANES adult participants reporting grapefruit consumption. One cannot rule out uncertainty due to the potential lack of representativeness of the consumption patterns of the sample number of grapefruit consumers. In addition, it is important to note that the findings are based on cross-sectional data; consequently no conclusions of the causal relationship between grapefruit consumption and improved nutrition status, diet quality, or metabolic health can be made.

In summary, a small percentage of adults reported consumption of grapefruit. Males were more likely to consume juice, and women were more likely to consume the fruit. Consumption of grapefruit was associated with improved adequacy of intake of key nutrients including vitamin C and magnesium, and a greater proportion of adults meeting recommended intakes of dietary fiber. In addition, grapefruit consumers had significantly better diet quality compared to non-consumers. Among women in this cross-sectional study, grapefruit consumption was associated with lower body weight, waist circumference, BMI, triglycerides, and CRP, and higher HDL cholesterol. Grapefruit consumption was not, however, associated with reduced risk of being overweight or obese. This is a cross-sectional study; therefore, causality of the observed effects cannot be determined. Dietary guidance encourages consumption of a nutrient-dense diet rich in fruits and vegetables. Currently, a small proportion of the population consumes grapefruit. Grapefruit, including both the fruit and 100% juice, may provide an additional option for many adults striving to consume a healthful diet with increased levels of fruits.

References

1. US Department of Health and Human Services, US Department of Agriculture. Dietary Guidelines for Americans, 7th ed. Washington, DC: US Government Printing Office; 2010.
2. Krebs-Smith SM, Guenther PM, Subar AF, Kirkpatrick SI, Dodd KW. Americans do not meet federal dietary recommendations. J Nutr 2010; 140: 1832–8.
3. Kimmons J, Gillespie C, Seymour J, Serdula M, Blanck HM. Fruit and vegetable intake among adolescents and adults in the United States: percentage meeting individualized recommendations. Medscape J Med 2009; 11: 26.
4. Code of Federal Regulations. Title 21, Part 101 – Food labeling, Subpart G – exemptions from food labeling requirements: appendix C to part 101 – nutrition facts for raw fruits and vegetables. US Government Printing Office. http://www.ecfr.gov/cgi-bin/retrieve ECFR?gp=1&SID=c880ef379537b77746b24e59217513c0&ty=HTML&h=L&r=APPENDIX&n=21y2.0.1.1.2.7.1.4.3 [cited 26 March 2013].
5. US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group. Composition of foods, raw, processed, Prepared USDA National Nutrient Database for Standard Reference, Release 25. Beltsville, MD. http://www.ars.usda.gov/Services/docs.htm?docid=8964 [cited 26 March 2013].
6. Rampersaud GC. A comparison of nutrient density scores for 100% fruit juices. J Food Sci 2007; 72: S261–6.
7. Rampersaud G, Valim MF, Barros S. Calculation and comparison of nutrient density/quality scores for commonly consumed fresh fruit. Alim Nutr, Araraquara 2012; 23: 7–14.
8. Holden JM, Eldridge AL, Beecher GR, Marilyn Buzzard I, Bhagwat S, Davis CS, et al. Carotenoid content of U.S. foods: anupdate of the database. J Food Compost Anal 1999; 12: 169–96.

9. US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group. USDA database for the flavonoid content of selected foods, Release 3. Beltsville, MD. http://www.ars.usda.gov/Services/docs.htm?docid=6231 [cited 21 December 2011].

10. Chanet A, Milenkovic D, Manach C, Mazur A, Morand C. Citrus flavanones: what is their role in cardiovascular protection? J Agric Food Chem 2012; 60: 8809–22.

11. Golechha M, Chaudhry U, Bhatia J, Saluja D, Arya DS. Naringin protects against kainic acid-induced status epilepticus in rats: evidence for an antioxidant, anti-inflammatory and neuroprotective intervention. Biol Pharm Bull 2011; 34: 360–5.

12. Kim SY, Kim HJ, Lee MK, Jeon SM, Do GM, Kwon EY, et al. Naringin time-dependently lowers hepatic cholesterol biosynthesis and plasma cholesterol in rats fed high-fat and high-cholesterol diet. J Med Food 2006; 9: 582–6.

13. Wei M, Yang Z, Li P, Zhang Y, Sse WC. Anti-osteoporosis activity of naringin in the retinoic acid-induced osteoporosis model. Am J Chin Med 2007; 35: 663–7.

14. Mink PJ, Scrafford CG, Barraj LM, Harnack L, Hong CP, Nettleton JA, et al. Flavonoid intake and cardiovascular disease mortality: a prospective study in postmenopausal women. Am J Clin Nutr 2007; 85: 895–909.

15. Dauchet L, Ferrieres J, Arveiler D, Yarnell JW, Gey F, Ducimetiere P, et al. Frequency of fruit and vegetable consumption and coronary heart disease in France and Northern Ireland: the PRIME study. Br J Nutr 2004; 92: 963–72.

16. Joshipura KJ, Ascherio A, Manson JE, Stampfer MJ, Rimm EB, Speizer FE, et al. Fruit and vegetable intake in relation to risk of ischemic stroke. JAMA 1999; 282: 1233–9.

17. Smiciklas-Wright H, Mitchell DC, Mickle SJ, Cook AJ, Goldman JD. Foods commonly eaten in the United States: quantities consumed per eating occasion and in a day, 1994–96. US Government Printing Office. http://www.ars.usda.gov/SP2UserFiles/Place/12355000/pdf/Portion.pdf [cited 12 February 2012].

18. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2003–2004 Dietary Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Dietary&CycleBeginYear=2003 [cited 21 December 2011].

19. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2005–2006 Dietary Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Dietary&CycleBeginYear=2005 [cited 21 December 2011].

20. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2007–2008 Dietary Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Dietary&CycleBeginYear=2007 [cited 21 December 2011].

21. US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group. USDA food and nutrient database for dietary studies, 4.1. Beltsville, MD. http://www.ars.usda.gov/Services/docs.htm?docid=20511 [cited 21 December 2011].

22. US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group. USDA food and nutrient database for dietary studies, 3.0. Beltsville, MD. http://www.ars.usda.gov/Services/docs.htm?docid=17031 [cited 21 December 2011].

23. US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group. USDA food and nutrient database for dietary studies, 2.0. Beltsville, MD. http://www.ars.usda.gov/Services/docs.htm?docid=12083 [cited 21 December 2011].

24. Guenther PM, Reedy J, Krebs-Smith SM. Development of the Healthy Eating Index-2005. J Am Diet Assoc 2008; 108: 1896–901.

25. Bowman S, Friday J, Moshfegh A. MyPyramid Equivalents Database, 2.0 for USDA Survey Foods, 2003–2004. Beltsville, MD: Food Surveys Research Group. Beltsville Human Nutrition Research Center, Agricultural Research Service, U.S. Department of Agriculture. http://www.ars.usda.gov/Services/docs.htm?docid=17563 [cited 21 December 2011].

26. Koegel KL, Kuczynski KJ. Center for Nutrition Policy and Promotion Addendum to the MyPyramid Equivalents Database 2.0. Alexandria, VA: USDA Center for Nutrition Policy and Promotion, Nutrition Guidance and Analysis Division.

27. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2003–2004 Examination Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Examination&CycleBeginYear=2003 [cited 21 December 2011].

28. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2005–2006 Examination Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Examination&CycleBeginYear=2005 [cited 21 December 2011].

29. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2007–2008 Examination Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Examination&CycleBeginYear=2007 [cited 21 December 2011].

30. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2003–2004 Laboratory Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Laboratory&CycleBeginYear=2003 [cited 21 December 2011].

31. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2005–2006 Laboratory Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Laboratory&CycleBeginYear=2005 [cited 21 December 2011].

32. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2007–2008 Laboratory Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Laboratory&CycleBeginYear=2007 [cited 21 December 2011].

33. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2003–2004 Demographics Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Demographics&CycleBeginYear=2003 [cited 21 December 2011].

34. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2005–2006 Demographics Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Demographics&CycleBeginYear=2005 [cited 21 December 2011].

35. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2007–2008 Demographics Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Demographics&CycleBeginYear=2007 [cited 21 December 2011].

36. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2003–2004 Questionnaire Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Questionnaire&CycleBeginYear=2003 [cited 21 December 2011].

37. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2005–2006 Questionnaire Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Questionnaire&CycleBeginYear=2005 [cited 21 December 2011].

38. Centers for Disease Control and Prevention, National Center for Health Statistics. National Health and Nutrition Examination Survey 2007–2008 Questionnaire Data. http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Questionnaire&CycleBeginYear=2007 [cited 21 December 2011].

39. Zhang Z, Cogswell ME, Gillespie C, Fang J, Loustalot F, Dai S, et al. Association between usual sodium and potassium intake and blood pressure and hypertension among U.S. adults: NHANES 2005–2010. PLoS One 2013; 8: e75289.

40. Nusser SM, Carriquiry AL, Dodd KW, Fuller WA, Jensen HH. A user's guide to C-SIDE: software for intake distribution estimation, Version 1.0, Technical Report 96-TR 31. Iowa State University, IA; 1996.

41. Guenther PM, Kott PS, Carriquiry AL. Development of an approach for estimating usual nutrient intake distributions at the population level. J Nutr 1997; 127: 1106–12.

42. Insitute of Medicine (2000). Dietary reference intakes: applications in dietary assessment. Wasington, DC: National Academy Press.

43. US Department of Agriculture, Center for Nutrition Policy and Promotion. Healthy Eating Index. Beltsville, MD. http://www.cnpp.usda.gov/healthyeatingindex.htm [cited 18 February 2013].

44. O'Neil CE, Nicklas TA, Rampersaud GC, Fulgoni VL, 3rd. 100% orange juice consumption is associated with better diet quality, improved nutrient adequacy, decreased risk for obesity, and improved biomarkers of health in adults: National Health and Nutrition Examination Survey, 2003–2006. Nutr J 2012; 11: 107.

45. US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group. National Nutrient Database for Standard Reference Release 25: Nutrient data for 09112, Grapefruit, raw, pink and red, all areas. Beltsville, MD. http://ndb.nal.usda.gov/ndb/foods/show/2240 [cited 26 April 2013].

46. US Department of Agriculture, Agricultural Research Service, Food Surveys Research Group. National Nutrient Database for Standard Reference Release 25: Nutrient data for 09116, Grapefruit, raw, white, all areas. Beltsville, MD. http://ndb.nal.usda.gov/ndb/foods/show/2243 [cited 13 March 2013].

47. Fujioka K, Greenway F, Sheard J, Ying Y. The effects of grapefruit on weight and insulin resistance: relationship to the metabolic syndrome. J Med Food 2006; 9: 49–54.

48. Dow CA, Going SB, Chow HH, Patil BS, Thomson CA. The effects of daily consumption of grapefruit on body weight, lipids, and blood pressure in healthy, overweight adults. Metabolism 2012; 61: 1026–35.

49. Silver HJ, Dietrich MS, Niswender KD. Effects of grapefruit, grapefruit juice and water preloads on energy balance, weight loss, body composition, and cardiometabolic risk in free-living obese adults. Nutr Metab (Lond) 2011; 8: 8.

50. Gorinstein S, Caspi A, Libman I, Lerner HT, Huang D, Leontowicz H, et al. Red grapefruit positively influences serum triglyceride level in patients suffering from coronary athero-sclerosis: studies in vitro and in humans. J Agric Food Chem 2006; 54: 1887–92.

51. Landberg R, Sun Q, Rimm EB, Cassidy A, Scalbert A, Mantzoros CS, et al. Selected dietary flavonoids are associated with markers of inflammation and endothelial dysfunction in U.S. women. J Nutr 2011; 141: 618–25.

52. Diaz-Juarez JA, Tenorio-Lopez FA, Zarco-Olvera G, Valle-Mondragon LD, Torres-Narvaez JC, Pastelin-Hernandez G. Effect of Citrus paradisi extract and juice on arterial pressure both in vitro and in vivo. Phytother Res 2009; 23: 948–54.

53. Reshef N, Hayari Y, Goren C, Boaz M, Madar Z, Knobler H. Antihypertensive effect of sweetie fruit in patients with stage I hypertension. Am J Hypertens 2005; 18: 1360–3.

54. Gorinstein S, Caspi A, Libman I, Katrich E, Lerner HT, Trakhtenberg S. Fresh israeli jaffa sweetie juice consumption improves lipid metabolism and increases antioxidant capacity in hypercholesterolemic patients suffering from coronary artery disease: studies in vitro and in humans and positive changes in albumin and fibrinogen fractions. J Agric Food Chem 2004; 52: 5215–22.

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