

# Tomato consumption is associated with improved diet quality and lower C-reactive protein in adults

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## ABSTRACT

Using data from adults aged 19 years and older in the National Health and Nutrition Examination Survey (1999–2004), we compared individuals who consumed  $\geq 1/4$  cup (n = 1,851) of processed tomatoes to those who consumed  $<1/4$  cup processed tomatoes (n = 11,441). Consumption of processed tomatoes was associated with significantly lower serum C-reactive protein ( $0.39 \pm 0.01$  v  $0.43 \pm 0.01$  mg/dl, p<0.05), greater intake of five nutrients of concern, and higher total vegetable intake. After adjustment for gender, ethnicity, age, and caloric intake, adult processed tomato consumers had greater intake of dietary fiber ( $19.7 \pm 0.4$  vs.  $15.1 \pm 0.02$  g, p < 0.01), potassium ( $3133 \pm 32$  vs.  $2688 \pm 18$  mg, p < 0.01), magnesium ( $315 \pm 3$  vs.  $279 \pm 2$  mg, p < 0.01), vitamin C ( $107.4 \pm 3.0$  vs.  $90.2 \pm 1.9$  mg, p<0.01), vitamin E ( $9.0 \pm 0.1$  vs  $6.8 \pm 0.1$  mg AT, p<0.01) and total vegetable intake ( $2.30 \pm 0.05$  vs.  $1.53 \pm 0.02$  cups/d, p<0.01) than non-consumers. Sodium intake was higher ( $3962 \pm 39$  vs.  $3387 \pm 18$  mg, p < 0.01) in consumers but blood pressure was not different ( $123.4/72.1$  vs.  $122.9/72.0$  mm Hg). Overall, these findings suggest processed tomato consumption is associated with improved diet quality and with a reduction in C-reactive protein, a CVD risk marker.

## BACKGROUND

- Observational studies show that an increased C-reactive protein level, a marker for inflammation, is associated with greater risk of CVD.<sup>1</sup>
- A randomized four-week clinical trial in healthy adults consuming tomato juice (500 ml per day) with and without vitamin C revealed significant reductions in C-reactive protein in both groups.<sup>2</sup>
- A dietary pattern that includes a high consumption of fruit and vegetables is significantly and inversely related to C-reactive protein concentrations.<sup>3,4,5</sup>
- The Dietary Guidelines for Americans (DGA) encourage the consumption of tomatoes and/or tomato products to obtain daily requirements for vitamin A, C and potassium.<sup>6</sup>
- The DGA has also stated, "Compared with the many people who consume a dietary pattern with only small amounts of fruits and vegetables, those who eat more generous amounts as part of a healthful diet are likely to have reduced risk of chronic diseases, including stroke and perhaps other cardiovascular diseases".<sup>6</sup>

## PURPOSE

To examine the association of processed tomato consumption to nutrient intake, food group intake, and chronic disease risk factors in adults aged 19 years and older in the National Health and Nutrition Examination Survey (1999–2004).

## METHODS

**Subjects**  
 • 1999-2004 NHANES participants, which included adults 19+ years of age (n = 13,292) with reliable 24-hour recall dietary interviews meeting minimum criteria

**Description of Dataset**  
 • NHANES is a continuous survey conducted by the National Center for Health Statistics with survey data released every two years  
 • The present analysis combined 3 NHANES datasets (NHANES 1999-2000, NHANES 2001-2002, and NHANES 2003-2004)  
 • Processed tomato consumers were individuals who reported consumption of tomato products (i.e., cooked and canned tomatoes, tomato sauce, tomato juice and tomato-based condiments, including ketchup, salsa and BBQ sauce), during a 24-hour dietary recall  
 • Groups Examined: Individuals who consumed  $\geq 1/4$  cup (n=1,851) of processed tomatoes to those who consumed  $<1/4$  cup processed tomatoes (n=11,441)

**Analysis**  
 • Data were analyzed using SUDAAN Release 9.0.1 (RTI International; Research Triangle Park, North Carolina)  
 • Least square means, standard errors and ANOVA were calculated using appropriate sample weights following adjustment for age, gender, ethnicity and energy

## RESULTS

### Least-Square Mean Daily Nutrient Intake by Processed Tomato Consumption Adults 19+ Years-Old

Nutrient	Tomato Sauce and Other Processed Tomato		
	Total Adults (n = 13,292)	$\geq 1/4$ Cup (n = 1,851)	$< 1/4$ Cup (n = 11,441)
Food Energy (Kcal)	2218 ± 10	2387 ± 26	2192 ± 12
Protein (g)	82.3 ± 0.4	84.0 ± 0.9	82.1 ± 0.4
Total Fat (g)	83.0 ± 0.4	77.5 ± 0.7	83.9 ± 0.4
Saturated Fat (g)	27.2 ± 0.1	25.2 ± 0.3	27.5 ± 0.1
Monounsaturated Fat (g)	31.1 ± 0.2	29.0 ± 0.3	31.5 ± 0.2
Polyunsaturated Fat (g)	17.2 ± 0.1	15.9 ± 0.2	17.4 ± 0.1
Cholesterol (mg)	289 ± 3	270 ± 6	292 ± 3
Carbohydrate (g)	273 ± 1	289 ± 2	270 ± 1
Total Dietary Fiber (g)	15.7 ± 0.2	19.7 ± 0.4	15.1 ± 0.2
Vitamin A (µg RAE)	611 ± 10	587 ± 15	614 ± 11
Alpha Tocopherol (mg)	7.1 ± 0.1	9.0 ± 0.1	6.8 ± 0.1
Vitamin C (mg)	92.5 ± 1.9	107.4 ± 3.0	90.2 ± 1.9
Total Folate (µg)	398 ± 4	459 ± 7	389 ± 5
Calcium (mg)	857 ± 7	874 ± 17	854 ± 8
Phosphorus (mg)	1328 ± 6	1359 ± 13	1323 ± 6
Magnesium (mg)	283 ± 2	315 ± 3	279 ± 2
Iron (mg)	15.6 ± 0.1	17.7 ± 0.2	15.3 ± 0.1
Sodium (mg)	3464 ± 16	3962 ± 39	3387 ± 18
Potassium (mg)	2747 ± 17	3133 ± 32	2688 ± 18

Source: NHANES, 1999-2004, ages 4 years and older, excluding pregnant/lactating females. Sample-weighted least-square mean and standard error are estimated using PROC REGRESS of SUDAAN. Covariates with nutrients include energy (Kcal), gender, race-ethnicity, and age (years). Gender, race-ethnicity, and age (years) were covariates with energy (Kcal).  
 \* Tomato consumption groups differ significantly at p < 0.05  
 \*\* Tomato consumption groups differ significantly at p < 0.01

### Least-Square Mean Biochemical Level by Processed Tomato Consumption Adults 19+ Years-Old

Biochemical Parameter	Tomato Sauce and Other Processed Tomato		
	Total Adults (n = 13,292)	$\geq 1/4$ Cup (n = 1,851)	$< 1/4$ Cup (n = 11,441)
<sup>2</sup> Total cholesterol (mg/dL)	202.3 ± 0.6 n = 12,553	203.3 ± 1.3 n = 1,759	202.1 ± 0.6 n = 10,794
<sup>2</sup> LDL-cholesterol (mg/dL)	120.7 ± 0.7 n = 5,583	120.3 ± 1.6 n = 745	120.8 ± 0.8 n = 4,838
<sup>2</sup> HDL-cholesterol (mg/dL)	51.9 ± 0.3 n = 12,551	51.8 ± 0.5 n = 1,759	51.9 ± 0.3 n = 10,792
<sup>2</sup> Triglyceride (mg/dL)	147.1 ± 2.9 n = 5,744	147.4 ± 5.0 n = 779	147.1 ± 3.1 n = 4,965
<sup>2</sup> Glucose, plasma (mg/dL)	100.9 ± 0.4 n = 5,821	100.7 ± 1.2 n = 786	101.0 ± 0.4 n = 5,035
<sup>2</sup> Insulin (uU/mL)	11.6 ± 0.2 n = 5,735	11.7 ± 0.4 n = 777	11.6 ± 0.2 n = 4,958
<sup>1</sup> C-reactive protein (mg/dL)	0.42 ± 0.01 n = 12,626	0.39 ± 0.01* n = 1,769	0.43 ± 0.01 n = 10,857

Source: NHANES, 1999-2004, ages 4 years and older, excluding pregnant/lactating females. Sample-weighted least-square mean and standard error are estimated using PROC REGRESS of SUDAAN.  
<sup>1</sup> Covariates include energy (Kcal), gender, race-ethnicity, and age (years).  
<sup>2</sup> Covariates include energy (Kcal), gender, race-ethnicity, age (years), and BMI (kg/m<sup>2</sup>).  
 \* Tomato consumption groups differ significantly at p < 0.05  
 \*\* Tomato consumption groups differ significantly at p < 0.01

### Least-Square Mean Body Weight and Blood Pressure by Processed Tomato Consumption Adults 19+ Years-Old

Examination Component	Tomato Sauce and Other Processed Tomato		
	Total Adults (n = 13,292)	$\geq 1/4$ Cup (n = 1,851)	$< 1/4$ Cup (n = 11,441)
<sup>1</sup> Weight (kg)	80.4 ± 0.3 n = 13,041	80.2 ± 0.4 n = 1,818	80.5 ± 0.3 n = 11,223
<sup>1</sup> Body Mass Index (kg/m <sup>2</sup> )	28.1 ± 0.1 n = 12,929	27.9 ± 0.1 n = 1,805	28.1 ± 0.1 n = 11,124
<sup>1</sup> Waist circumference (cm)	96.3 ± 0.3 n = 12,815	96.0 ± 0.4 n = 1,782	96.3 ± 0.3 n = 11,033
<sup>2</sup> Systolic BP (mmHg)	123.0 ± 0.3 n = 12,796	123.4 ± 0.6 n = 1,791	122.9 ± 0.3 n = 11,005
<sup>2</sup> Diastolic BP (mmHg)	72.0 ± 0.2 n = 12,796	72.1 ± 0.4 n = 1,791	72.0 ± 0.2 n = 11,005

Source: NHANES, 1999-2004, ages 4 years and older, excluding pregnant/lactating females. Sample-weighted least-square mean and standard error are estimated using PROC REGRESS of SUDAAN.  
<sup>1</sup> Covariates include energy (Kcal), gender, race-ethnicity, and age (years).  
<sup>2</sup> Covariates include energy (Kcal), gender, race-ethnicity, age (years), and BMI (kg/m<sup>2</sup>).  
 \* Tomato consumption groups differ significantly at p < 0.05  
 \*\* Tomato consumption groups differ significantly at p < 0.01

### Least-Square Mean Daily MyPyramid Food Group Intake by Processed Tomato Consumption Adults 19+ Years-Old

My Pyramid Food Group	Tomato Sauce and Other Processed Tomato		
	Total Adults (n = 13,292)	$\geq 1/4$ Cup (n = 1,851)	$< 1/4$ Cup (n = 11,441)
Total grains (oz)	6.79 ± 0.05	7.60 ± 0.11	6.67 ± 0.06
Whole grains (oz)	0.66 ± 0.02	0.71 ± 0.03	0.65 ± 0.02
Non-whole grains (oz)	6.13 ± 0.05	6.88 ± 0.11	6.02 ± 0.05
Total vegetables (cup)	1.64 ± 0.02	2.30 ± 0.05	1.53 ± 0.02
Tomato (cup)	0.36 ± 0.01	1.14 ± 0.03	0.24 ± 0.01
Total fruit (cup)	1.01 ± 0.03	1.04 ± 0.04	1.01 ± 0.03
Meat, poultry, fish (oz)	4.84 ± 0.06	4.37 ± 0.15	4.91 ± 0.06
Cooked dry beans & peas (cup)	0.12 ± 0.00	0.20 ± 0.02	0.10 ± 0.00
Oil (gram)	18.6 ± 0.2	16.9 ± 0.5	18.8 ± 0.3
Solid fat (gram)	47.2 ± 0.3	42.5 ± 0.6	47.9 ± 0.3
Added sugars (tsp)	22.1 ± 0.4	19.5 ± 0.4	22.5 ± 0.4
Alcohol (drinks)	0.90 ± 0.04	0.69 ± 0.08	0.93 ± 0.04

Source: NHANES, 1999-2004, ages 4 years and older, excluding pregnant/lactating females. Sample-weighted least-square mean and standard error are estimated using PROC REGRESS of SUDAAN.  
 Covariates include energy (Kcal), gender, race-ethnicity, and age (years).  
 \* Tomato consumption groups differ significantly at p < 0.05  
 \*\* Tomato consumption groups differ significantly at p < 0.01

## CONCLUSIONS

- Processed tomato consumption was associated with significantly lower C-reactive protein, a CVD risk marker.
- Higher consumption of processed tomatoes was associated with greater nutrient density in comparison to lower processed tomato intake—nutrient intake included significantly more dietary fiber, potassium, magnesium, vitamin C, and vitamin E.
- Consumption of  $\geq 1/4$  cup of processed tomatoes was also associated with reduced intake of oil, solid fat and added sugars in comparison to those who consumed  $< 1/4$  cup daily.
- While sodium intake was higher ( $3962 \pm 39$  vs.  $3387 \pm 18$  mg, p < 0.01) in adults consuming greater processed tomatoes, blood pressure was not different between the two groups examined ( $123.4/72.1$  vs.  $122.9/72.0$  mm Hg).

## SIGNIFICANCE

- CVD is a major cause of death in the US, accounting for approximately 40% of all deaths each year—modifiable risk factors for CVD includes improper nutrition.<sup>7</sup>
- This study further emphasizes that adults who consume processed tomato products also consume higher levels of key nutrients that play a role in cardiovascular health, including dietary fiber, potassium, magnesium, and vitamin C.
- The results from this secondary analysis are in accordance with previously published fruit and vegetable literature showing a positive association with cardiovascular parameters.

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