

NOT ALL FRUITS AND VEGETABLES ARE EQUAL: COLORS OF FRUITS AND VEGETABLES AND DIABETES RISK IN THE U.S. LATINO POPULATION

Raymond Colon, MS student; Zhiping Yu, PhD, RD, LDN, Associate Professor, University of North Florida, Jacksonville, FL USA 32224

INTRODUCTION

- Colors of fruits and vegetables (FV) have been associated with reduced risk of some chronic diseases.¹
- In the United States (US), the Centers for Disease Control and Prevention (CDC) estimate the prevalence of type 2 diabetes (DM) in the US Hispanic/Latino population to be 16.9%, 6.7% higher than the estimated prevalence of US non-Hispanic White adults.²
- Previous research on the topic focused on other health problems and populations such as Europeans and Chinese individuals. This study is the first to examine FV colors on DM in the US Hispanic/Latino population.

- As of 2019, results on this topic have been mixed. Some studies suggest berries and green, leafy vegetables can reduce risk², while most studies did not specify the association between colors of FV and diabetes risk.

OBJECTIVE

- The current study aimed to identify if specific colors of FVs are associated with type 2 diabetes risk in the United States Hispanic/Latino population.

METHODS

- This study used a subgroup of participants from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). This is a multi-center, prospective cohort study with 16,415 self-identified Hispanic/Latino individuals from 2008-2011.^{3,4}
- Data collected include anthropometrics, oral glucose tolerance test (OGTT), dietary intake, and sociodemographic information.^{3,4} FVs are categorized into five color groups: green, white, yellow/orange, red/purple, and uncategorized.

F&V Color Categories- from Food Propensity Questionnaire		
Green (G)-8	White (W)-6	
<ul style="list-style-type: none">28- cooked greens (spinach, turnip, collard, mustard, chard, kale)29- raw greens (spinach, turnip, collard, mustard, chard, kale)32- peas34- broccoli38- lettuce salads (with or without other vegetables)38a- dark green lettuce salads (spinach or romaine)50- nopal	<ul style="list-style-type: none">13- applesauce14- apples15- pears16- bananas42- potatoes51- plantain	
Yellow/Orange (O)-11	Uncategorized-9	
<ul style="list-style-type: none">17- pineapple19- peaches/nectarines/plums23- oranges/tangerines/clementines/angelos25- mango26- papaya/lechosa/tuta bomba30- carrots33- corn37- summer squash (yellow and green squash)39- yams/sweet potatoes48- winter squash (pumpkin, acorn, butternut squash)49- avocado	<ul style="list-style-type: none">18- dried fruit (prunes, raisins)21- melons (cantaloupe, watermelon, honeydew)27- other fruit35- mix veggies40- French fries/home fries/hash43- salsa/salsa de pollo de pollo52- other kind of vegetables	
Red/Purple (R)-4	Skipped Questions	
<ul style="list-style-type: none">20- grapes22- strawberries24- grapefruit36- tomato	<ul style="list-style-type: none">45- chili46- tortillas or tacos46a- tortillas or tacos corn tortillas or tacos47- cooked dried beans	

- Dietary intake data used for analysis comes from two 24hr food recalls spaced six weeks apart.
- Using the *Food Patterns Equivalents Database 2009-10 (FPED)* from the *USDA*, foods were converted to a 1 cup equivalent and a 1 serving equivalent. Averages were calculated by participant, day, color and total.
- All data was analyzed using SAS 9.2.

RESULTS

- A total of 5,740 participants (ages 18-74, BMI 29.5, female 55.2%, US born 21.4%, confirmed DM 13.6%) were included in the analysis.

Table 1. Sociodemographic characteristics of Hispanic and Latino adults by tertiles of fruit and vegetable intake: HCHS/SOL, 2008-2011				
	n	All (0-36.7 servings/day) n=5740	Below Median (0-3.0 servings/day) N=2823	Above Median (3.1-36.7 servings/day) N=2917
Age (y)		41.9±0.4	40.8±0.4	43.0±0.5
BMI (kg/m ²)		29.5±0.1	29.6±0.2	29.4±0.2
Gender, %				
	Female	3564	55.2	54.9
	Male	2176	44.8	45.1
Center, %				
	Bronx	1373	27.7	29.9
	Chicago	1370	14.8	15.7
	Miami	1553	32.3	33.3
	San Diego	1444	25.2	21.1
Yearly Household Income, %				
	\$10,000 or less	793	13.1	14.8
	\$10,001 - \$20,000	1751	28.8	28.2
	\$20,001 - \$40,000	1769	30.8	29.3
	\$40,001 - \$75,000	708	13.2	13.8
	\$75,001 or more	229	5.1	6.4
	Not reported	490	9.0	7.8
Education level, %				
	Less than high school	2181	33.1	34.3
	High School or equivalent	1400	26.4	28.4
	>High school or equivalent	2147	40.3	43.6
	Not reported	12	0.1	0.2
Background, %				
	Dominican	497	10.2	9.2
	Central American	598	7.7	8.7
	Cuban	924	22.7	23.7
	Mexican	2231	35.8	31.4
	Puerto Rican	939	14.2	17.8
	South American	384	5.0	4.4
	Others/Mixed	167	4.5	4.8
Years Living in the U.S., %				
	US born	972	21.4	25.8
	Not US born but ≥10 years	4408	72.5	74.0
	Not US born but <10 years	1310	27.5	26.0
Confirmed Diabetes*, %				
	Yes	1030	13.6	13.1
	No	4685	86.4	86.9
BMI, %				
	<18.5 kg/m ² (underweight)	34	0.9	0.9
	18.5 - 24.9 kg/m ² (healthy weight)	1082	21.2	22.1
	25 - 29.9 kg/m ² (overweight)	2154	37.4	34.8
	≥30 kg/m ² (obese)	2458	40.5	42.2
Cigarette pack years		5.3 ± 0.3	6.0 ± 0.4	4.7 ± 0.4
Energy intake (kcal/d)		1968.8 ± 11.5	1915.1 ± 14.1	2023.1 ± 16.1
PUFA (g/d)		15.4 ± 0.1	15.1 ± 0.1	15.6 ± 0.2
trans fatty acids (g/d)		2.7 ± 0.02	2.7 ± 0.03	2.7 ± 0.03
Whole grain (servings/d)		1.5 ± 0.04	1.4 ± 0.05	1.6 ± 0.06
Red and processed meat (servings/d)		1.04 ± 0.01	1.06 ± 0.01	1.03 ± 0.02
SSB's (servings/d)		1.8 ± 0.02	1.8 ± 0.03	1.8 ± 0.03
Physical activity level, %				
	Inactive	1360	22.2	23.4
	Low activity	769	12.1	12.3
	Medium activity	629	10.6	10.9
	High activity	2951	55.0	53.4

BMI, body mass index; PUFA, polyunsaturated fatty acids; SSB, sugar-sweetened beverage. All data are presented as Mean ± SE or percentage. All analyses were weighted to adjust for sampling probability of selection and nonresponse. *Fasting glucose, post OGTT glucose, and HbA1C were measured for diabetes. If participants were high on one or more, they were considered to have diabetes. (FPG≥126mg/dl; or OGTT≥200mg/dl; or A1C≥6.5%)

- Table 1:* Participants 43 years old tend to consume more FV than average. A higher percentage of participants with higher education tend to consume more FV.

Table 2. Fruit and Vegetable intake by color groups by Hispanic/Latino heritage									
	Servings/day (min, max)	Dominican	Central American	Cuban	Mexican	Puerto Rican	South American	Others /mixed	All
Green	0, 11.0	0.3±0.04	0.4±0.04	0.4±0.03	0.5±0.03	0.3±0.03	0.6±0.06	0.5±0.07	0.4±0.02
White	0, 14.6	1.5±0.1	0.9±0.06	0.9±0.06	0.9±0.05	0.8±0.05	1.1±0.09	0.9±0.2	1.0±0.03
Yellow/Orange	0, 11.6	0.4±0.05	0.4±0.04	0.3±0.03	0.6±0.03	0.2±0.02	0.5±0.05	0.3±0.09	0.4±0.02
Red/Purple	0, 12.2	0.1±0.02	0.2±0.02	0.2±0.02	0.2±0.02	0.1±0.01	0.3±0.04	0.2±0.04	0.2±0.01
Uncategorized	0, 22.9	1.5±0.2	1.4±0.08	1.8±0.1	1.8±0.07	1.4±0.07	2.0±0.2	1.5±0.2	1.7±0.05
All	0, 36.7	3.8±0.2	3.3±0.1	3.6±0.2	4.0±0.1	2.8±0.1	4.4±0.3	3.4±0.3	3.6±0.07

- Table 2:* The red/purple FV were the least consumed. Excluding the uncategorized group, white FV had the highest consumption across all color groups. Puerto Ricans consume the least FV compared to other groups.

Table 3. Intake of fruit and vegetable color groups and cardiometabolic risk factors in HCHS/SOL (2008-2011)										
	Log-BMI (kg/m ²)	Log-HbA1c (%)	Log-glucose (mg/dL)	Log-OGTT glucose (mg/dL)	Log-insulin (μmol/L)	Log-total cholesterol (mg/dL)	Log-HDL (mg/dL)	Log-LDL (mg/dL)	Log-TG (mg/dL)	
All										
Unadjusted										
Below median	3.37±0.006	1.73±0.004	4.59±0.005	4.72±0.01	2.35±0.02	5.24±0.005	3.86±0.007	4.73±0.008	4.68±0.01	
Above median	3.36±0.005	1.74±0.004	4.60±0.005	4.73±0.01	2.35±0.02	5.26±0.006	3.86±0.007	4.75±0.008	4.76±0.02	
P-value	0.42	0.19	0.20	0.26	0.94	0.01	0.77	0.11	0.0006	
Adjusted										
Below median	3.38±0.006	1.75±0.004	4.61±0.005	4.79±0.01	2.36±0.02	5.27±0.005	3.88±0.006	4.77±0.008	4.74±0.013	
Above median	3.38±0.005	1.76±0.004	4.62±0.006	4.78±0.01	2.36±0.02	5.27±0.005	3.87±0.007	4.77±0.008	4.78±0.016	
P-value	0.97	0.18	0.11	0.71	0.99	0.75	0.41	0.75	0.07	
Green										
Unadjusted										
Below median	3.37±0.005	1.73±0.004	4.59±0.005	4.72±0.009	2.37±0.02	5.24±0.006	3.85±0.007	4.73±0.008	4.73±0.01	
Above median	3.36±0.006	1.74±0.004	4.59±0.006	4.73±0.01	2.34±0.02	5.26±0.006	3.87±0.007	4.75±0.009	4.71±0.02	
P-value	0.57	0.28	0.98	0.70	0.28	0.07	0.06	0.08	0.25	
Adjusted										
Below median	3.38±0.005	1.75±0.004	4.61±0.005	4.78±0.009	2.37±0.02	5.27±0.005	3.87±0.006	4.76±0.008	4.77±0.01	
Above median	3.37±0.005	1.76±0.004	4.62±0.006	4.78±0.01	2.35±0.02	5.28±0.006	3.88±0.006	4.78±0.008	4.75±0.01	
P-value	0.74	0.34	0.60	0.83	0.50	0.11	0.66	0.07	0.40	
Red/Purple										
Unadjusted										
Below median	3.37±0.005	1.74±0.003	4.60±0.005	4.72±0.008	2.37±0.02	5.25±0.005	3.85±0.006	4.75±0.007	4.72±0.01	
Above median	3.34±0.008	1.73±0.004	4.59±0.006	4.72±0.01	2.30±0.03	5.25±0.008	3.87±0.01	4.74±0.01	4.71±0.02	
P-value	0.0005	0.09	0.57	0.92	0.016	0.81	0.04	0.54	0.57	
Adjusted										
Below median	3.38±0.005	1.75±0.003	4.61±0.005	4.78±0.008	2.38±0.02	5.27±0.004	3.87±0.005	4.77±0.006	4.77±0.01	
Above median	3.36±0.008	1.75±0.004	4.61±0.006	4.78±0.01	2.30±0.03	5.27±0.007	3.89±0.009	4.76±0.01	4.74±0.02	
P-value	0.002	0.11	0.98	0.91	0.01	0.84	0.02	0.33	0.25	
Yellow/Orange										
Unadjusted										
Below median	3.37±0.005	1.73±0.004	4.60±0.005	4.71±0.009	2.36±0.02	5.24±0.005	3.84±0.006	4.74±0.008	4.71±0.01	
Above median	3.36±0.007	1.74±0.004	4.59±0.006	4.74±0.01	2.34±0.02	5.26±0.006	3.88±0.008	4.76±0.009	4.73±0.02	
P-value	0.18	0.11	0.47	0.05	0.53	0.009	0.0007	0.07	0.33	
Adjusted										
Below median	3.38±0.005	1.75±0.003	4.62±0.005	4.79±0.009	2.37±0.02	5.27±0.005	3.87±0.006	4.77±0.007	4.77±0.01	
Above median	3.37±0.006	1.76±0.004	4.61±0.006	4.78±0.01	2.35±0.02	5.27±0.006	3.88±0.008	4.77±0.009	4.75±0.02	
P-value	0.13	0.80	0.26	0.62	0.61	0.85	0.17	0.83	0.59	
White										
Unadjusted										
Below median	3.36±0.006	1.73±0.004	4.59±0.005	4.70±0.01	2.35±0.02	5.24±0.005	3.85±0.007	4.73±0.008	4.69±0.02	
Above median	3.37±0.005	1.74±0.004	4.60±0.006	4.75±0.01	2.36±0.02	5.26±0.005	3.87±0.007	4.75±0.008	4.75±0.02	
P-value	0.74	0.003	0.098	<0.0001	0.80	0.0003	0.073	0.046	0.0023	
Adjusted										
Below median	3.37±0.005	1.75±0.004	4.61±0.005	4.77±0.01	2.36±0.02	5.27±0.005	3.88±0.007	4.77±0.008	4.74±0.01	
Above median	3.38±0.005	1.76±0.003	4.62±0.006	4.80±0.01	2.36±0.02	5.28±0.005	3.87±0.007	4.77±0.008	4.79±0.02	
P-value	0.64	0.28	0.52	0.04	0.87	0.21	0.52	0.70	0.02	
Uncategorized										
Unadjusted										
Below median	3.38±0.005	1.74±0.005	4.61±0.006	4.73±0.01	2.36±0.02	5.24±0.005	3.86±0.007	4.74±0.007	4.71±0.02	
Above median	3.35±0.006	1.72±0.003	4.58±0.005	4.71±0.01	2.35±0.02	5.25±0.006	3.85±0.007	4.75±0.009	4.73±0.02	
P-value	0.0013	0.0002	0.0004	0.16	0.68	0.28	0.50	0.21	0.31	
Adjusted										
Below median	3.38±0.005	1.76±0.004	4.62±0.006	4.79±0.01	2.37±0.02	5.27±0.005	3.87±0.007	4.76±0.007	4.76±0.01	
Above median	3.37±0.005	1.75±0.003	4.61±0.005	4.78±0.01	2.35±0.02	5.28±0.006	3.87±0.007	4.77±0.008	4.77±0.02	
P-value	0.04	0.09	0.06	0.40	0.45	0.43	0.82	0.47	0.79	

Data presented as Mean ± SE. All dependent variables were log-transformed due to skewed distributions. All analyses were weighted to adjust for sampling probability of selection and nonresponse. Adjusted model: adjusted for age, gender, heritage, site, physical activity, smoking, total energy intake, polyunsaturated fatty acids, trans fatty acids, whole grains, red and processed meat, sugar-sweetened beverage.

- Table 3:* Higher intake of red/purple FVs is associated with lower body mass index (BMI), lower insulin levels and higher high-density lipoproteins (HDL) levels. A higher intake of white FVs is associated with a higher OGTT glucose and triglyceride levels.

Table 4 Fruit and vegetable intake by color groupings on diabetes confirmation ¹				
		Below Median Reference	Above Median OR (95% CI)	P-value
Green	Unadjusted	1.00	0.96 (0.79, 1.15)	0.96
	Model 1	1.00	0.97 (0.80, 1.19)	0.78
Red/Purple	Unadjusted	1.00	0.85 (0.69, 1.03)	0.09
	Model 1	1.00	0.86 (0.69, 1.06)	0.15
Yellow/Orange	Unadjusted	1.00	1.10 (0.90, 1.35)	0.36
	Model 1	1.00	0.96 (0.76, 1.22)	0.75
White	Unadjusted	1.00	1.37 (1.15, 1.64)	0.0005
	Model 1	1.00	1.25 (1.02, 1.53)	0.03
Uncategorized	Unadjusted	1.00	0.68 (0.56, 0.82)	<0.0001
	Model 1	1.00	0.88 (0.70, 1.10)	0.25
All	Unadjusted	1.00	1.08 (0.90, 1.30)	0.42
	Model 2	1.00	1.19 (0.96, 1.46)	0.11