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

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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, medical history, physical activity, 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	
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Green (G)-8	White (W)-6
 28- cooked greens (spinach, turnip, collard, mustard, chard, kale) 29- raw greens (spinach, turnip, collard, mustard, chard, kale) 31- string beans/green beans 32- peas 34- broccoli 38- lettuce salads (with or without other vegetables) 38a- dark green lettuce salads (spinach or romaine) 50- nopal 	 13- applesauce 14- apples 15- pears 16- bananas 42- potatoes 51- plantain
Yellow/Orange (O)-11 • 17- pineapple	Uncategorized-9 • 18- dried fruit (prunes, raisins)
 19- peaches/nectarines/plums 23- oranges/tangerines/clementines/tangelos 25- mango 26- papaya/lechosa/fruta bomba 30- carrots 33- corn 37- summer squash (yellow and green squash) 39- yams/sweet potatoes 48- winter squash (pumpkin, acorn, butternut squash) 49- avocado 	 21- melons (cantaloupe, watermelon, honeydew) 27- other fruit 35- mix veggies 40- French fries/home fries/hash browned potatoes/tater tots 41- potato salad 44- ketchup 43- salsa/pico de gallo 52- other kind of vegetables
Red/Purple (R)-4	Skipped Questions
 20- grapes 22- strawberries 24- grapefruit 	 45-chili 46-tortillas or tacos 46a-tortillas or tacos corn tortillas or

- 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

		All	Below Median	Above Media
		(0-36.7	(0-3.0	(3.1-36.7
		servings/day)	servings/day)	servings/day
	n	n=5740	N=2823	N=2917
Age (y)		41.9±0.4	40.8±0.4	43.0±0.5
BMI (kg/m²)		29.5±0.1	29.6±0.2	29.4±0.2
Gender, %				
Female	3564	55.2	54.9	55.6
Male	2176	44.8	45.1	44.4
Center, %				
Bronx	1373	27.7	29.9	25.4
Chicago	1370	14.8	15.7	14.0
Miami	1553	32.3	33.3	31.3
San Diego	1444	25.2	21.1	29.3
Yearly Household Income, %	1444	23.2	21.1	25.5
	702	12.1	14.0	11.2
\$10,000 or less	793	13.1	14.8	11.3
\$10,001 - \$20,000	1751	28.8	29.4	28.2
\$20,001 - \$40,000	1769	30.8	29.3	32.4
\$40,001 - \$75,000	708	13.2	12.6	13.8
\$75,001 or more	229	5.1	3.7	6.4
Not reported	490	9.0	10.2	7.8
Education level, %				
Less than high school	2181	33.1	34.3	31.9
High School or equivalent	1400	26.4	28.4	24.4
>Higher school or equivalent	2147	40.3	37.1	43.6
Not reported	12	0.1	0.1	0.2
Background, %		0.1	0.1	0.2
Dominican	497	10.2	9.2	11.2
		10.2		11.2
Central American	598	7.7	8.7	6.7
Cuban	924	22.7	23.7	21.6
Mexican	2231	35.8	31.4	40.3
Puerto Rican	939	14.2	17.8	10.5
South American	384	5.0	4.4	5.7
Others/Mixed	167	4.5	4.8	4.1
Years Living in the U.S., %				
US born	972	21.4	25.8	16.9
Not US born but ≥10 years	4408	72.5	74.0	71.0
Not US born but <10 years	1310	27.5	26.0	29.0
Confirmed Diabetes*, %				
Yes	1030	13.6	13.1	14.0
No	4685	86.4	86.9	86.0
BMI, %		33.1	20.2	time time" in the
<18.5 kg/m² (underweight)	34	0.9	0.9	0.9
18.5 - 24.9 kg/m² (healthy weight)	1082	21.2	22.1	20.3
25 - 29.9 kg/m² (overweight)	2154	37.4	34.8	40.1
≥30 kg/m² (obese)	2458	40.5	42.2	38.7
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.:
PUFA (g/d)		15.4 ± 0.1	15.1±0.1	15.6±0.2
town r				
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	21.1
Low activity	769	12.1	12.3	12.0
Medium activity	629	10.6	10.9	10.4
High activity	2961	55.0	53.4	56.6

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. Fru	it and Vegetabl	e intake by colo	r groups by His	panic/Latino herita	ige		
	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
AII _	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 (2008-20 Log-BMI Log-HbA1c Log-glucose Log-post Log-insulin Log-total Log-HDL (kg/m²) (%) (mg/dL) QgTT (pmg/L) cholesterol (mg/dL) glucose (mg/dL) 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 Nove 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 P-value 0.42 0.19 0.20 0.26 0.94 0.01 0.77

					glucose (mg/dL)		(mg/dL)			
All										
	Unadjusted									
	elow 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
Al	bove 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
	P-value Adjusted	0.42	0.19	0.20	0.26	0.94	0.01	0.77	0.11	0.000
Bi	elow 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±0.0
	bove 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±0.0
	P-value	0.97	0.18	0.11	0.71	0.99	0.75	0.41	0.75	0.07
Green										
	Unadjusted									
Be	elow 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.
Al	bove 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.
	P-value	0.57	0.28	0.98	0.70	0.28	0.07	0.06	0.08	0.25
	Adjusted									
	elow 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.
Al	bove 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.
ייח/ וי	P-value	0.74	0.34	0.60	0.83	0.50	0.11	0.66	0.07	0.40
Red/Purple										
n.	Unadjusted elow median	2 2710 000	4 7410 000	4.5010.005	4 70 10 000	0.2710.00	E OF LO OOF	3.0510.005	4.7510.007	4.7010
	bove 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.
, n	P-value	3.34±0.008	1.73±0.004	4.59±0.006 0.57	4.72±0.01	2.30±0.03	5.25±0.008	3.87±0.01	4.74±0.01 0.54	4.71±0.
	Adjusted	0.0005	0.09	0.57	0.92	0.016	0.81	0.04	0.54	0.57
B.	elow median	3.38±0.005	1.76±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.
	bove median	3.36±0.005	1.75±0.003	4.61±0.005	4.78±0.008	2.30±0.02	5.27±0.004 5.27±0.007	3.89±0.009	4.77±0.006 4.76±0.01	4.74±0.
	P-value	0.002	0.11	0.98	0.91	0.01	0.84	0.02	0.33	0.25
ke ni da										
Yellow/Ora	_									
	Unadjusted low median	2 2740 005	1 7340 004	4.60±0.005	4 71+0 000	2 26+0 02	E 24±0 00E	2 04+0 000	4 74+0 000	4.71.
	ove median	3.37±0.005 3.36±0.007	1.73±0.004 1.74±0.004	4.59±0.006	4.71±0.009 4.74±0.01	2.36±0.02 2.34±0.02	5.24±0.005 5.26±0.006	3.84±0.006 3.88±0.008	4.74±0.008 4.76±0.009	4.71: 4.73:
, 10	P-value	0.18	0.11	0.47	0.05	0.53	0.009	0.0007	0.07	0.
	Adjusted	0.10	0.11	0.47	0.03	0.55	0.005	0.0007	0.07	O.
Ве	elow 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:
	ove median	3.37±0.006	1.76±0.003	4.61±0.006	4.78±0.003	2.35±0.02	5.27±0.005	3.88±0.008	4.77±0.009	4.75:
	P-value	0.13	0.80	0.26	0.62	0.61	0.85	0.17	0.83	0.
White		G. 22	er. ere	tor's decise	Seeff or Seeff dise	Ser. 62	0.00	Surviva salar of	an and	Nation .
	Unadjusted									
Ве	elow 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:
Ab	ove 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:
	P-value	0.74	0.003	0.098	<0.0001	0.80	0.0003	0.073	0.046	0.0
	Adjusted									
Ве	elow 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:
Ab	ove 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:
	P-value	0.64	0.28	0.52	0.04	0.87	0.21	0.52	0.70	0.
Uncategoria										
	Unadjusted									
	elow 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:
Ab	ove 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	4.735
	P-value	0.0013	0.0002	0.0004	0.16	0.68	0.28	0.50	0.21	0.
	Adjusted			, , , , , , , , , , , , , , , , , , , ,			p. 2000		,	
Ве	elow median ove 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:
A L	zove 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:
Ab	P-value	0.04	0.09	0.06	0.40	0.45	0.43	0.82	0.47	0.1

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.

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Table 4 Fruit and vegetable intake by color groupings on diabetes confirmation

Yellow/Orange 0.96 (0.76, 1.22) 0.75 1.37 (1.15, 1.64) 0.0005 Unadjusted 1.00 1.25 (1.02, 1.53) Uncategorized 0.68 (0.56, 0.82) 0.88 (0.70, 1.10) 0.25 1.08 (0.90, 1.30) Unadjusted 1.00 1.19 (0.96, 1.46)

¹Fasting 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%).

Model 1: 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, and mutually adjusted by other coloring groups.

Model 2: 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.

All analyses were weighted to adjust for sampling probability of selection and nonresponse.

DISCUSSION & CONCLUSION

- More research is needed to confirm results.
- Education should focus on consuming a variety of fruits and vegetables.
- Health professionals should continue promoting the current recommendation of offering 5-a-day fruits and vegetables.
- Future research should focus on identifying causes of low fruit and vegetable intake in Hispanic/Latino groups living in the US.

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• Table 4: Consumption of a higher amount of white FVs daily has higher odds of having diabetes (OR=1.25, p=0.03).