Mangos are Associated with Better Nutrient Intake, Diet Quality, and Levels of Some Cardiovascular Risk Factors: National Health and Nutrition Examination Survey

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Introduction

Mangos are a stone fruit belonging to the tropical genus *Mangifera*. There are several species; however, *M. indicaL* is the most commonly cultivated and is available worldwide. In 2010, India was the top producer of mangos, and accounted for more than half of the world production, with more than 16,000,000 MT [1]. Global demand is high [1]; however, mangos are not widely consumed in the US. The Economic Research Service estimated in 2009 that per capita availability, adjusted for loss was 0.084 lbs/year [2].

One cup (165 grams [g]) of raw mango provides approximately 100 kilocalories (Kcals), 23 g total sugars, 3 g dietary fiber, nearly 1,800 IU vitamin A, 60 mg vitamin C, 16 mg magnesium, and 280 mg potassium [3]. Thus, one cup of raw mangos can provide 7-12% of the Dietary Reference Intake for dietary fiber (depending on the age and gender of the individual), 80% and 100% of the Estimated Average Requirements of vitamin C for males and females, respectively, and approximately 6% of the Adequate Intake for potassium [4]. In addition, mangos contain virtually no total fat, Saturated Fatty Acids (SFA), or sodium, and no cholesterol [3].

Mangos are also a rich source of carotenoids [3] and polyphenols, including flavonoids such as quercetin and kaempferol glycosides, phenolic acids, such as gallic acid, galloyl glycosides, and mangiferin, a xanthonoid [5]. Studies in humans are lacking; however, studies in experimental animals suggest that these compounds in mangos are antioxidants and anti-inflammatory [6-10]. Freeze-dried mango preparations, fed to mice receiving high fat diets, reduce the epididymal fat mass and the percentage of body fat and to improve glucose tolerance and insulin resistance [11], suggesting these preparations may reduce the risk of type 2 diabetes or Metabolic Syndrome (MetS). Other studies, using extracts of bark and mango stem lower blood glucose levels in streptozotocin-induced diabetic rats [12,13] and hyperglycemic rats [14] and mice [15,16]. Human studies that examined the effect of mango on health parameters are scarce. We have been unable to find studies that have looked at the association of the consumption of mango flesh on nutrient intake, diet quality, and health biomarkers in humans. Thus, the purpose of this study was to examine the association between mango consumption and dietary quality, nutrient intake and physiological parameters in a nationally representative sample of adults and children using National Health and Nutrition Examination Survey

(NHANES), 2001-2008 data.

Materials and Methods

Study population and analytic sample

For the present analyses, data from children 2-18 y (n=11,974) and adults 19+ y (n=17,568) participating in the NHANES 2001-2008 were combined to increase sample size [17]. Analyses included only individuals with reliable dietary records; females who were pregnant or lactating (n=1,174) were excluded from the analyses. The NHANES has stringent protocols and procedures that ensure confidentiality and protect individual participants from identification using federal laws [18]. This was a secondary data analysis which lacked personal identifiers; therefore, this study did not need institutional review [19].

Demographics and dietary information

Demographic information was determined from the NHANES interview [20]. Intake data were obtained from What We Eat in America (WWEIA) which used in-person 24 hour dietary recall interviews administered using an automated multiple-pass method [21,22]. In 2001-2002, a single 24 hour dietary recall was collected; however, beginning in 2003-2004, two days of intake were collected. For consistency, only the data from the Day 1 dietary recall were used in this study. Detailed descriptions of the dietary interview methods are provided in the NHANES Dietary Interviewers Procedure Manual [20].

To identify mango consumers, the following food codes from the USDA Food and Nutrient Database for Dietary Studies [23] were used: 63129010 – mango, raw; 63129020 – mango, pickled; 63129030 – mango, cooked; and 62114050 – mango, dried; there were no mango juice consumers. Individuals were classified as consumers if any mango was ingested the day of the recall. For each participant, daily total energy and nutrient intakes from foods and beverages were obtained from the total nutrient intake files associated with each data release. Intake from supplements was not considered.

Food group equivalent intakes and healthy eating index (HEI-2005)

Food group equivalent intakes (formerly called MyPyramid equivalents) were determined using My Pyramid Equivalents Database 2.0; when necessary, food group equivalent intakes from NHANES 2005-2006 and 2007-2008 were hand matched to similar foods. The HEI-2005 was used to determine diet quality and to evaluate adherence to the 2005 Dietary Guidelines for Americans [24]. The SAS code used to calculate HEI-2005 scores was downloaded from the Center for Nutrition Policy and Promotion website [25].

Anthropometric and physiological measures

Height, weight, and Waist Circumference (WC) were obtained according to NHANES protocols [26]. Body mass index was calculated as body weight (kilograms) divided by height (meters) squared [27]. For the Odds Ratio (OR) assessments, described below, overweight/ obesity and high WC were determined using the National Heart Lung and Blood Institute Clinical Guidelines [27]. Systolic (SBP) and Diastolic Blood Pressures (DBP) were determined using the standard NHANES protocol [28]. Total and high density lipoprotein-cholesterol (HDL-C) were determined on non-fasted individuals [29] while low density lipoprotein-cholesterol (LDL-C) LDL [30], triglycerides [30], blood glucose [31], and insulin [31] were determined on only fasted subjects; thus, not all individuals may have values for all tests. Metabolic syndrome was defined using the National Heart Lung and Blood Institute Adult Treatment Panel III criteria [32]; that is having 3 or more of the following risk factors: abdominal obesity, WC>102 cm (males), >88 cm (females); hypertension, SBP ≥ 130 mmHg or DBP ≥ 85 mmHg or taking anti-hypertensive medications; HDL-cholesterol, <40 mg/dL (males), <50 mg/dL (females); high triglycerides, ≥ 150 mg/ dL or taking anti-hyperlipidemic medications; high fasting glucose, ≥ 110 mg/dL or taking insulin or other hypoglycemic agents.

Statistical analyses

Sampling weights and the primary sampling units and strata information, as provided by NHANES [17], were included in all analyses using SUDAAN v10.0 (Research Triangle Institute; Raleigh, NC). Least-square means (and the standard errors of the least-square means) were calculated using PROC REGRESS of SUDAAN. Linear regression was used to determine differences in mango consumers and non-consumers for food, nutrient, and physiologic measures. Logistic regression was used to determine if mango consumers had a lower odds ratio (OR) of being overweight or obese or having other cardiovascular health risk factors. For all linear and logistic regressions, covariates were age, gender, ethnicity, poverty index ratio [33], and physical activity level [34], smoking status, and alcohol consumption [33]. Energy (Kcals) was used for regressions in the nutrient analyses except when Kcals were the dependent variable. Body Mass Index was used as a covariate in the biophysical linear regressions except when the dependent variable was body weight, BMI, or WC. A p value of <0.05 was considered significant.

Results

Study population and mango consumption

Subjects included children 2-18 y (n=11,974; 50% female) and adults 19+ y (n=17,568; 48.8% female). Per capita average consumption of mangos by children and adults was 0.9 ± 0.2 g/d and 0.8 ± 0.1 g/d; whereas as average intake among consumers (n=103 children; n=117 adults) was 140.2 ± 6.06 g/d and 141 ± 7 g/d.

Food group equivalents

In children, mango consumers had higher intakes of total fruit (2.38 ± 0.26 Cup Equivalent [CE]/d v 1.07 ± 0.02 CE/d; p<0.001) and whole fruit (1.53 ± 0.26 CE/d v 0.53 ± 0.02 CE/d; p=0.0002) than nonconsumers and a lower intake of whole grains (0.27 ± 0.09 oz eq/d v 0.50 ± 0.01oz eq/d; p=0.0146). No other differences were seen between consumption of food group equivalents. In adults, higher (p<0.0001) intakes of total and whole fruit were seen in consumers than nonconsumers (2.5 ± 0.2 CE/d v 1.0 ± 0.0 cup eq/d and 2.00 ± 0.2 cup eq/d v and 0.6 ± 0.01 cup eq/d, respectively) (Table 1). A lower (p=0.0244) intake of total grains and total dairy (p=0.0153) was seen in mango consumers than in non-consumers (6.1 ± 0.3 oz eq/d v6.8 ± 0.0 oz eq/d and 1.3 ± 0.1 cup eq/d v 1.6 ± 0.0cup eq/d, respectively). No differences were seen between the groups.

Age	Food Group	LSM-C ± SE	LSM-NC ± SE	Beta	P
2-18 Years	Total Fruit (cup eq)	2.38 ± 0.26	1.07 ± 0.02	1.32	<0.0001
2-18 Years	Fruit Juice (cup eq)	0.85 ± 0.18	0.53 ± 0.01	0.32	0.0744
2-18 Years	Whole Fruit (cup eq)	1.53 ± 0.26	0.53 ± 0.02	1.00	0.0002
2-18 Years	Total Grain (oz eq)	6.85 ± 0.60	6.74 ± 0.05	0.12	0.8469
2-18 Years	Whole Grain (oz eq)	0.27 ± 0.09	0.50 ± 0.01	-0.23	0.0146
2-18 Years	Total Dairy (cup eq)	2.46 ± 0.25	2.20 ± 0.03	0.26	0.3058
2-18 Years	Milk (cup eq)	1.94 ± 0.26	1.44 ± 0.03	0.51	0.0506
2-18 Years	Total Vegetable (cup eq)	1.12 ± 0.22	1.00 ± 0.02	0.11	0.6158
19+ Years	Total Fruit (cup eq)	2.51 ± 0.16	1.00 ± 0.02	1.51	<0.0001
19+ Years	Fruit Juice (cup eq)	0.52 ± 0.13	0.39 ± 0.01	0.13	0.3318
19+ Years	Whole Fruit (cup eq)	1.99 ± 0.16	0.61 ± 0.01	1.38	<0.0001
19+ Years	Total Grain (oz eq)	6.05 ± 0.33	6.80 ± 0.04	-0.74	0.0244
19+ Years	Whole Grain (oz eq)	0.88 ± 0.28	0.69 ± 0.02	0.19	0.5035
19+ Years	Total Dairy (cup eq)	1.31 ± 0.10	1.58 ± 0.02	-0.27	0.0153
19+ Years	Milk (cup eq)	0.82 ± 0.07	0.86 ± 0.02	-0.04	0.6240
19+ Years	Total Vegetable (cup eq)	1.87 ± 0.15	1.63 ± 0.02	0.24	0.1125

Covariates: Age, Gender, Ethnicity, Poverty Index Ratio, Physical Activity Level, Smoker Status, Alcohol Consumption are used for all linear regressions.

Abbreviations: LSM = least square mean; SE = standard error; C= mango consumer; NC = non-mango consumers.
Table 1: Association of Consuming Mangos with Food Group Equivalents in Children and Adults Participating in the 2001-2008 National Health and Nutrition Examination Survey.

Energy, micronutrient, and macronutrient intakes and HEI- 2005

In children, total sugar intake was higher in mango consumers (154.86 ± 4.04 g/d v 140.13 ± 0.89 g/d; p=0.0007) than in nonconsumers; however, added sugar intake was lower (16.90 ± 1.75 tsp eq/d v 21.60 ± 0.22 tsp eq/d; p=0.0098) (Table 2). Consumers also had a lower intake of monounsaturated fatty acids (24.84 ± 0.95 g/d v 27.57 ± 0.14 g/d; p=0.0075). Mango consumers had higher intakes of vitamin A (783.35 ± 73.86 RAE mcg v 583.04 ± 8.22 RAE mcg; p=0.0099), vitamin C (130.98 ± 13.36 mg/d v 83.23 ± 1.20 mg/d; 0.0007), calcium (1175.45 ± 81.25 mg/d v 997.31 ± 8.73; p=0.0321), and potassium (2632.02 ± 172.68 mg/d v 2209.00 ± 17.09 mg/d; p=0.0157). Children that consumed mangos also had a higher HEI-2005 score than non-consumers (57.42 ± 1.28 v 49.01 ± 0.28; p<0.0001).

	Children				Adults			
Variable	LSM-C ± SE	LSM-NC ± SE	Beta	P	LSM-C ± SE	LSM-NC ± SE	Beta	P
Energy (kcal)	2449.26 ± 287.51	2007.77 ± 11.67	441.49	0.1299	2151.5 ± 84.1	2190.2 ± 10.9	-38.7	0.6495
Protein (gm)	69.84 ± 2.09	69.37 ± 0.34	0.47	0.8279	78.8 ± 3.2	83.2 ± 0.3	-4.4	0.1730
Carbohydrate (gm)	280.98 ± 7.51	271.19 ± 0.80	9.79	0.2085	290.0 ± 5.7	265.9 ± 0.9	24.2	<0.0001
Total sugars (gm)	154.86 ± 4.04	140.13 ± 0.89	14.73	0.0007	146.9 ± 4.8	124.6 ± 0.9	22.3	<0.0001
Added Sugar (tsp eq)	16.90 ± 1.75	21.60 ± 0.22	-4.70	0.0098	17.6 ± 1.1	19.6 ± 0.3	-2.1	0.0330
Dietary fiber (gm)	14.32 ± 1.03	12.58 ± 0.11	1.74	0.0932	21.7 ± 1.3	15.8 ± 0.2	5.9	<0.0001
Total fat (gm)	70.46 ± 2.56	74.25 ± 0.29	-3.79	0.1507	76.9 ± 2.2	83.1 ± 0.3	-6.2	0.0049
SFA (gm)	25.43 ± 1.38	26.25 ± 0.12	-0.82	0.5570	23.2 ± 0.9	27.4 ± 0.1	-4.2	<0.0001
MUFA (gm)	24.84 ± 0.95	27.57 ± 0.14	-2.73	0.0075	27.6 ± 1.0	30.8 ± 0.1	-3.2	0.0028
PUFA (gm)	14.31 ± 0.89	14.31 ± 0.11	-0.01	0.9946	18.2 ± 0.9	17.4 ± 0.1	0.8	0.3526
Cholesterol (mg)	209.54 ± 20.88	223.32 ± 2.30	-13.78	0.5184	226.2 ± 15.8	290.9 ± 2.4	-64.7	0.0001
Vitamin A, RAE (mcg)	783.35 ± 73.86	583.04 ± 8.22	200.31	0.0099	648.0 ± 45.0	618.7 ± 9.0	29.3	0.5304
Thiamin (mg)	1.69 ± 0.09	1.56 ± 0.01	0.13	0.1681	1.7 ± 0.1	1.7 ± 0.0	0.0	0.9012
Vitamin B6 (mg)	1.91 ± 0.12	1.69 ± 0.02	0.22	0.0758	2.3 ± 0.1	1.9 ± 0.0	0.3	0.0032

Folate, DFE (mcg)	500.00 ± 33.68	536.14 ± 4.73	-36.14	0.2693	553.0 ± 29.0	543.4 ± 4.7	9.5	0.7465
Vitamin C (mg)	130.98 ± 13.36	83.23 ± 1.20	47.75	0.0007	159.4 ± 9.9	87.9 ± 1.6	71.5	<0.0001
Calcium (mg)	1175.45 ± 81.25	997.31 ± 8.73	178.14	0.0321	839.9 ± 43.0	911.2 ± 7.1	-71.2	0.1011
Magnesium (mg)	246.96 ± 11.93	226.28 ± 1.31	20.68	0.0858	341.6 ± 17.4	290.0 ± 1.8	51.6	0.0041
Iron (mg)	14.11 ± 0.61	14.54 ± 0.09	-0.43	0.4918	14.9 ± 0.6	15.7 ± 0.1	-0.8	0.2286
Sodium (mg)	2867.67 ± 109.56	3072.31 ± 16.78	-204.64	0.0698	3116.3 ± 99.4	3490.0 ± 12.2	-373.7	0.0004
Potassium (mg)	2632.02 ± 172.68	2209.00 ± 17.09	423.02	0.0157	3240.2 ± 97.6	2713.0 ± 13.6	527.2	<0.0001
Healthy Eating Index	57.42 ± 1.28	49.01 ± 0.28	8.40	<0.0001	60.8 ± 1.3	50.9 ± 0.2	9.9	<0.0001

Table 2: Energy, Macronutrient, Micronutrient, and Healthy Eating Index-2005 in Children and Adults Consuming and Not Consuming Mangos.

Data source: Children 2-18 years of age and adults 19+ years of age participating in NHANES 2001-2008

Covariates: Age, Gender, Ethnicity, Poverty Index Ratio, Physical Activity Level, Smoker Status, Alcohol Consumption were used for all linear and logistic regressions.

Kcal was used for regressions in the nutrient analysis section except when Kcal is the dependent variable.

Abbreviations: LSM = least square mean; SE = standard error; C= consumer (of mangos); NC = non-consumer (of mangos); SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids

In adults, mean intake of total carbohydrates (p<0.0001), total sugars, and dietary fiber (p<0.0001) was higher in mango consumers than in non-consumers (290.0 ± 5.7 g/d v 265.9 ± 0.9 g/d, 146.9 ± 4.8 g/d v 124.6 ± 0.9 g/d, and 21.7 ± 1.3g/d v 15.8 ± 0.2 g/d, respectively) (Table 2). Added sugar intake was significantly lower (p=0.0330) in consumers than in non-consumers (17.6 ± 1.1 tsp eq/d v 19.6 ± 0.3 tsp eq/d). Mean intake of total fat (p=0.0049), SFA (p<0.0001), MUFA (p=0028), and cholesterol (p=0.0001) was lower in mango consumers than in non-consumers (76.9 ± 2.2 g/d v 83.1 ± 0.3 g/d, 23.2 ± 0.9 g/d v 27.4 ± 0.1 g/d, 27.6 ± 1.0 g/d v 30.8 ± 0.1 g/d, and 266.2 ± 15.8 mg/d v 290.9 ± 2.4 mg/d, respectively) than in non-consumers. No other differences for either energy or macronutrients were observed.

Mango consumers had higher intakes of vitamins B6 (2.3 ± 0.1 mg/d v 1.94 ± 0.0 mg/d; p=0.0032) and C (159.4 ± 9.9 mg/d v 87.9 ± 1.6 mg/d; p<0.0001); magnesium (341.6 ± 17.4 mg/d v 290.0 ± 1.8 mg/d; p=0.0004); and potassium (3240.2 ± 97.6 mg/d v2713.0 ± 13.6 mg/d; p<0.0001) than non-consumers (Table 2). Mango consumers also had a lower (p=0.0004) sodium intake (3116.3 ± 99.4 mg/d v 3490.0 ± 12.2 mg/d) than non-consumers. No other differences in micronutrients were seen between consumers and non-consumers. Finally, mango consumers had a higher (p<0.0001) HEI-2005 score (60.8 ± 1.3 v 50.9 ± 0.2) than non-consumers.

Physiologic measures

Table 3 shows that adult mango consumers weighed less than non-consumers (77.4 ± 1.9 kg v 81.6 ± 0.4 kg; p=0.0455) . C-reactive protein levels were also less (p=0.0374) in consumers than non-consumers (0.3 ± 0.0 mg/dL v0.4 ± 0.0 mg/dL) . There were no other differences in mean values for physiologic measures observed. Mango consumers had a higher prevalence of low HDL-C levels than non-consumers (0.6 ± 0.1 v 0.4 ± 0.0; p=0.0082) and elevated triglycerides (0.6 ± 0.1 v 0.4 ± 0.0; p=0.0156). This was consistent with the findings from the OR analyses, which showed an OR 1.89 (95% Confidence Interval [CI] 1.20-2.97; p = 0.0066) for the risk of low HDL-C levels in consumers and an OR for elevated triglycerides of 2.15 (95% CI 1.16-4.0; p=0.0161) (Table 4).

Variable	LSM-C ± SE	LSM-NC ± SE	Beta	P
Weight (kg)	77.4 ± 1.9	81.6 ± 0.4	-4.1	0.0455
Body Mass Index (kg/m$_2$)	27.4 ± 0.6	28.5 ± 0.1	-1.0	0.0844
Waist Circumference (cm)	95.5 ± 1.4	97.6 ± 0.3	-2.1	0.1483
BP Systolic (mm Hg)	122.0 ± 1.6	122.8 ± 0.3	-0.8	0.6290

BP Diastolic (mm Hg)	69.8 ± 1.5	71.2 ± 0.2	-1.4	0.3505
Vitamin C (mg/dL)	1.1 ± 0.1	1.0 ± 0.0	0.1	0.0808
C-reactive protein (mg/dL)	0.3 ± 0.0	0.4 ± 0.0	-0.1	0.0374
Total cholesterol (mg/dL)	206.4 ± 4.5	199.2 ± 0.6	7.1	0.1246
HDL-C (mg/dL)	51.6 ± 1.6	53.2 ± 0.2	-1.6	0.3013
LDL-C (mg/dL)	120.9 ± 7.1	116.1 ± 0.6	4.8	0.4982
Triglyceride (mg/dL)	149.8 ± 13.3	140.4 ± 2.0	9.5	0.4707
Apolipoprotein (B) (mg/dL)	98.0 ± 6.1	97.1 ± 0.7	0.9	0.8766
Glucose, plasma (mg/dL)	107.8 ± 5.6	103.2 ± 0.4	4.6	0.4096
Insulin (uU/mL)	12.9 ± 1.2	11.1 ± 0.2	1.8	0.1301
Folate, RBC (ng/mL RBC)	302.3 ± 14.9	292.1 ± 2.8	10.2	0.4898
Folate, serum (ng/mL)	15.9 ± 1.3	14.0 ± 0.2	1.9	0.1334
Variable	**Prevalence- C ± SE**	**Prevalence- NC ± SE**	**Beta**	**P**
Overweight	0.3 ± 0.1	0.3 ± 0.0	-0.0	0.9062
Obese	0.3 ± 0.0	0.3 ± 0.0	-0.1	0.0823
Overweight or Obese	0.6 ± 0.1	0.7 ± 0.0	-0.1	0.2179
LDL-C Elevated	0.7 ± 0.1	0.7 ± 0.0	0.0	0.7249
Waist Circumference Elevated	0.5 ± 0.1	0.5 ± 0.0	-0.0	0.5257
BP Elevated	0.4 ± 0.0	0.4 ± 0.0	-0.1	0.2448
HDL-C Reduced	0.6 ± 0.1	0.4 ± 0.0	0.2	0.0082
Triglycerides Elevated	0.6 ± 0.1	0.4 ± 0.0	0.2	0.0156
Glucose Elevated	0.5 ± 0.1	0.4 ± 0.0	0.1	0.2576
Metabolic Syndrome	0.5 ± 0.1	0.4 ± 0.0	0.0	0.5695

Table 3: Association of Consuming Mangos with Physiologic Measures in Adults participating in 2001-2008 NHANES.

Covariates: Age, Gender, Ethnicity, PIR, Physical Activity Level, Smoker Status, Alcohol Consumption was used for all linear and logistic regressions.BMI was used in biophysical linear regressions except when the dependent variable is body weight, BMI, waist circumference or any risk factor variable.

Abbreviations: LSM = least square mean, SE = standard error; C= consumer (of mangos); NC = non-consumer (of mangos); LDL-C = low density lipoprotein-cholesterol; WC = waist circumference; BP = blood pressure; HDL-C = high density lipoprotein-cholesterol.

Risk Variable	OR	LCL	UCL	P
Overweight	0.96	0.50	1.84	0.9061
Obese	0.68	0.42	1.10	0.1117
Overweight or Obese	0.68	0.37	1.23	0.1972
LDL-C Elevated	1.14	0.52	2.50	0.7324
WC Elevated	0.85	0.52	1.38	0.5077
BP Elevated[1]	0.72	0.42	1.25	0.2368
HDL-C Reduced	1.89	1.20	2.97	0.0066
Triglycerides Elevated	2.15	1.16	34.00	0.0161
Glucose Elevated	1.42	0.76	2.68	0.2673
Metabolic Syndrome	1.16	0.66	2.03	0.5966

Table 4: Risk of Overweight and Obesity and Cardiovascular and Metabolic Syndrome Risk Factors in Adults among Consumers and Non-Consumers of Mangos. Data source:

Adults 19+ years of age participating in NHANES 2001-2008

1 Mean readings were used for blood pressure measurements

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Covariates: Age, Gender, Ethnicity, Poverty Index Ratio, Physical Activity Level, Smoker Status, Alcohol Consumption was used for all linear and logistic regressions.BMI was used in biophysical linear regressions except when the dependent variable is body weight, BMI, waist circumference.

Abbreviations: LSM = least square mean; SE = standard error; C= mango consumer; NC = non-mango consumers; BP = blood pressure; HDL-C = high density lipoprotein-cholesterol; LDL-C = low density lipoprotein-cholesterol.

Discussion

The association of mango consumption and intake of food group equivalents and nutrients varied between children and adults. Mango consumption was associated with higher intake of total fruit, higher intakes of and potassium in children and adults; mean calcium intake was higher in children and mean dietary fiber intake was higher in adults. The 2010 Dietary Guidelines for Americans (DGA) identifies dietary fiber, calcium, and potassium as nutrients of public health concern [35].

Lower intake of added sugars and higher intake of vitamin C was seen in both children and adults. Adult mango consumers also had lower intakes of DGA-identified “nutrients to limit”, including SFA, cholesterol, and sodium. Children and adults that consumed mangos had better overall diet quality. Adult mango consumers had lower mean body weights and lower levels of C-reactive protein.

That mango consumers had higher intakes of total fruit compared with non-consumers was not surprising. However, mango consumption only accounted for approximately 0.81 CE in children and 0.85 CE in adults of the total fruit intake, suggesting that other fruits were also consumed in higher amounts. On average, those consuming mangos exceeded the requirement for fruit intake promulgated by My Plate [36], whereas those not consuming mangos did not. Most Americans do not consume adequate amounts of fruit [37-39]; to help individuals meet the requirements, it’s important that fruit be available and accessible, and that individuals understand the importance of consuming fruit. Most fruit is naturally low in energy and whole fruit has been shown to increase satiety [40], thus potentially leading to lower weight. Consumption of fruit is associated with a variety of health benefits; including reduced likelihood of dyslipidemia [41], high blood pressure [42], stroke [43], type 2 diabetes mellitus [44], and some types of cancer [45]. Consumption of fruit also has an inverse relationship with weight [46]. Consumption of mangos may be an important strategy to help Americans get closer to meeting the recommendation for fruit intake.

Children that consumed mangos had only a 2 g higher intake of dietary fiber; whereas adult consumers had nearly 6 g more of dietary fiber than non-consumers. On average, however, the dietary fiber intake of consumers would meet the requirements for females 50+y only. In adults, the dietary fiber intake of mango consumers was higher than the fiber content of the average amount of mango consumed, suggesting that other high fiber foods, including were contributing to overall fiber intake suggesting that mango consumers may have an overall healthier diet than non-consumers. Dietary fiber intake has been associated with health benefits including improved weight status, serum cholesterol levels, blood pressure, and blood sugar control [47]. Dietary fiber also decreases insulin resistance and is inversely associated with risk of type 2 diabetes [48]. Although adults consuming mangos had lower weight, they did not show a better cardiovascular or diabetes risk factor profile, than non-consumers.

Mango consumers also had higher intakes of potassium. The Institute of Medicine’s recommendations for potassium are 3,000 mg/d, 3,800 mg/d, 4,500 mg/d and 4,700 mg/d for those individuals 1-3 y, 4-8 y, 9-13 y, and those 14+ y, respectively [4]. These levels were chosen to help maintain blood pressure levels, blunt any adverse effects of sodium intake on blood pressure, and potentially decrease bone loss. Recent studies have suggested that the sodium-to-potassium intake ratio represents a more important risk factor for hypertension and cardiovascular disease than each factor alone [49,50]. Thus, it is important to encourage intake of foods low in sodium, but high in potassium, such as fresh or dried fruit.

In this study, mango consumption was associated with better overall diet quality as indicated by the higher total HEI-2005 score in consumers compared to non-consumers. Subcomponent scores were not examined; however, food group equivalents showed increased intake of total fruit which likely contributed to the overall score. Nutrient intake of children and adults consuming mangos showed lower intakes of added sugars; adult consumers also had lower intakes of SFA and sodium than non-consumers which likely also contributed to the overall higher diet quality observed.

In light of the higher total fruit, dietary fiber, and potassium intakes and lower intakes of added sugars, SFA, and sodium (in adults only), it was surprising that there were no differences between mango consumers and non-consumers in the majority of cardiovascular and diabetes risk factors. This study did show lower levels of CRP in adult mango consumers than in non-consumers. C-reactive protein is an inflammatory marker associated with cardiovascular and other inflammatory diseases. Previous studies have shown an inverse association of CRP and fruit and vegetable consumption, in general [51-53], and specifically with intake of strawberries [54] and purple fruit and vegetables [55]; this is the first study that has shown this association with mango consumption. Recently, however, one study [56], also using NHANES data, showed that there was no relationship between fruit and vegetable consumption and CRP levels. That study used highly controlled models and it is possible that the authors over controlled the analysis. However, it clearly suggests that further research is needed.

It was surprising that weight and CRP level were the only cardiovascular or diabetes risk factors associated with mango consumption since studies with laboratory animals have suggested that mango preparations may improve these risk factors in humans [6-15]. Many of those studies, however, used extracts of mango bark or stems, rather than the flesh, which may have active ingredients not present in the flesh or not present in sufficient quantities in the flesh to effect levels. It should also be noted that there were few mango consumers, which may have limited the ability to detect associations with biomarkers.

Limitations

Twenty-four hour dietary recalls have several inherent limitations. Participants relied on memory to self-report dietary intakes; therefore, data were subject to non-sampling errors, including underreporting of energy and examiner effects. The one-day intake used in this study may not represent usual intake of individuals over time. However, a single 24 hour dietary recall is appropriate when reporting mean group intakes [57]. Proxies reported or assisted with the 24 hour recalls of children 2-11 years of age; whereas parents often report accurately what children eat at home [58], but may not know what their children eat outside the home [59], which could result in reporting errors [60]. Further, since causal inferences cannot be drawn from NHANES analyses, and due to multi-co linearity of diet, foods other than mangos may have contributed to differences in nutrient intake of the participants. Finally, there were relatively small numbers of mango consumers in each age group.

Conclusions

Mango consumption was associated with a higher intake of whole fruit. Although results between the different age groups varied, in general, mango consumers had lower intakes of nutrients to limit, including added sugars, SFA, and sodium; higher intake of nutrients to encourage, including dietary fiber and potassium; better diet quality; and lower levels of CRP. Consumption of mangos and all fruit should be encouraged in an attempt to move Americans closer to meeting their recommendations for fruit intake, along with a healthy lifestyle. Nutrition educators should help individuals identify sources of fruit, including mangos, available to them and to help them incorporate these into the diet.

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