OKLAHOMA STATE UNIVERSITY

FINAL REPORT

Title of Study: Mango supplementation will improve glucose response and clinical parameters of pre-diabetic subjects

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INTRODUCTION

Diabetes afflicts approximately 29.1 million people (9.3% of the population) and was the seventh leading cause of death in the US in 2012.[1] The total cost associated with diabetes in 2012 is estimated to be $245 billion.[1] Diabetes is a disease marked by high levels of blood glucose resulting from defects in insulin production, insulin's action, or both.[1] Diabetes can cause complications to various organs such as the eyes, kidneys, heart, and nerves and can lead to premature death.[1]

Type 2 diabetes (T2D), also known as non-insulin-dependent diabetes mellitus, accounts for about 90 to 95 percent of all diagnosed cases of diabetes in adults.[1] T2D usually begins as insulin resistance, a disorder in which peripheral tissues (i.e. skeletal muscle and fat cells) do not properly utilize insulin, leading to increased demand for insulin produced by the pancreas. With this continuous and increased demand on the pancreas to produce more insulin, the pancreas gradually loses its ability to produce sufficient quantities of insulin ultimately leading to a hypoinsulinemic hyperglycemic condition.[1]

Pre-diabetics can delay or prevent the development of T2D by following a healthy diet and increasing physical activity.[1] It was demonstrated that pre-diabetics that engage in at least 30 minutes a day of moderate physical activity coupled with 5-10% reduction in body weight will reduce the development of T2D by 58%.[1] Similarly, people that have already been diagnosed with T2D can usually manage their blood glucose by following a healthy diet and exercise program, losing excess weight, and taking oral antidiabetic medications. Though there are several pharmacological options available for the treatment of diabetes, these options are often costly, exhibit negative side-effects, and long term compliance is often a problem.[2] Hence, there is a need for alternative therapies that have fewer side effects and can easily be incorporated into busy lifestyles. Investigating the role of dietary interventions that are effective, inexpensive,

easily incorporated into daily regimen, and are rich source of nutrients for other health benefits is a very appealing therapeutic option.

A diet containing a variety of fruits and vegetables has been reported to reduce the risk of many chronic diseases including T2D.[3] Fruits and vegetables contain bioactive compounds that can help delay the development of many chronic conditions. One fruit that is rich in bioactive components such as vitamin C, beta-carotene, phosphorus, and potassium, as well as fiber and phenolic compounds that have been shown to have health benefits is the mango fruit.[4] Mangos have been shown to contain a phenolic compound, mangiferin that exhibited anti-diabetic properties in animal models.[5-8] Results from our animal study also demonstrated that a diet containing freeze-dried mango, improved glucose response to a similar degree as the glucose-lowering drug, rosiglitazone in a mouse model of diet-induced obesity.[9] Additionally, two pilot human studies demonstrated that mango consumption favorably affects postprandial glucose and insulin response in T2D when compared to other tropical fruits.[10-11]

Despite our preliminary results and the work of others[5-11] related to the positive effect of mango consumption on improving glucose, evidence supporting the longer term effects of mango on glucose control, body weight and composition, and other key clinical parameters in individuals with moderately elevated blood glucose is not available. Therefore, this study investigated the effects of chronic mango consumption in modulating blood glucose levels and other clinical parameters in individuals with moderately elevated blood glucose. We *hypothesize* that freeze-dried mango due to its bioactive components will improve blood glucose concentrations and other clinical parameters in individuals with moderately elevated blood glucose.

APPROACH

Male and female adults between 18-70 years of age with mild to moderate fasting blood glucose (≥ 100 ≤ 126 mg/dL) and currently not taking glucose-lowering medications with normal liver and kidney function test were recruited in the study. In a cross-over study design, participants were asked to consume the pre-weighed, freeze-dried mango (10g/day) or placebo daily for 12 weeks with 3-4 weeks wash-out between treatments. No stipulations were given on how the supplement was to be consumed. Participants were also asked to maintain their normal diet, exercise, and lifestyle habits throughout the entire study.

Mango and placebo supplements were prepared on the campus of Oklahoma State University. Ripe Tommy Atkins variety mango was purchased from a local market, freeze-dried, ground into powder, and weighed into an opaque plastic bag (10 g/bag). The placebo was prepared using yellow colored sugar, fiber and powdered milk. The placebo supplement was adjusted to have similar carbohydrate, fat, protein and fiber content to that of the mango supplement and weighed into similar bags as the mango supplement.

Subjects came to the study site seven times and various questionnaires and measurements were done during each visit. They were provided a 6-week supply of pre-packaged ground freeze-dried ripe mango fruit powder or placebo and were asked to consume 1 packet daily. After consuming one of the treatment for 12 weeks, the participants came back for the other treatment after a 3-4 week washout period. The same questionnaires and measurements from the first arm of the study were done for the second arm of the study.

RESULTS

A. Thesis

Jessica Semkoff, MS student; Thesis Title: The effect of mango supplementation on clinical parameters of individuals with moderately elevated blood glucose. Thesis Defense: April 2015.

Crystal O'Hara, MS student; Thesis Title: The effects of mango on lipids, inflammatory markers, and oxidative stress in healthy young adult males following a typical breakfast meal. Thesis Defense: pending

B. Presentations at local and national meetings

Lucas EA. Functional food for heart health: focus on mango. *Oklahoma Baptist University, Science Club*, May 7, 2016.

O'Hara C, McMillen L, Simenson A, Ojo B, Smith BJ, Herman J, Lucas EA. The effects of mango supplementation on post-prandial responses in healthy young adult males following a high-fat meal challenge. Oklahoma Academy of Nutrition and Dietetics Symposium, April 14, 2016, Tulsa, OK

Semkoff J, Evans S, Janthachotikun SJ, Eldoumi H , Mahmood M, Meister M, Payton M, Peterson S, Perkins-Veazie P, Clarke SL, Smith BJ, Lucas EA. The effects of mango supplementation on clinical parameters of prediabetic individuals. Experimental Biology, March 2015; Boston, MA

Semkoff J, Evans S, Janthachotikun SJ, Eldoumi H , Mahmood M, Meister M, Payton M, Peterson S, Perkins-Veazie P, Clarke SL, Smith BJ, Lucas EA. The effects of mango supplementation on clinical parameters of prediabetic individuals. OSU Research Symposium, February 2015; Stillwater, OK.

Semkoff J, Evans S, Janthachotikun SJ, Eldoumi H , Mahmood M, Meister M, Payton M, Peterson S, Perkins-Veazie P, Clarke SL, Smith BJ, Lucas EA. The effects of mango supplementation on clinical parameters of prediabetic individuals. Oklahoma Academy of Nutrition and Dietetics Symposium, April 3, 2014, Tulsa, OK

C. Findings

Baseline characteristics (Table 1)

Twenty-eight individuals with slightly elevated blood glucose participated in the three-month study. Mean blood glucose at screening using a home testing glucometer (Onetouch, Shelton, CT) was 103.4 ± 3.7, and 106.9 ± 8.2 mg/dL for the mango and placebo treatments, respectively. Twenty-two individuals completed both arms of the study while six individuals finished only one arm of the study (four individuals only took the mango supplement while another two individuals took only the placebo). Therefore, twenty-six and twenty-four individuals received the mango and placebo supplement, respectively. The mean age of the participants was 38.8 ± 14.1 and 44.0 ± 15.4 years for the mango and placebo groups, respectively. There were no statistical differences in age, weight, height, BMI, screening blood glucose at baseline among the two groups.

Food intake and physical activity (Table 2)

There were no significant differences found in food intake of the subjects on either supplement before or at the end of treatment period. Vitamin C intake tended (P=0.062) to increase for the mango group after 12 weeks of supplementation. There was also no significant difference in the amount of physical activity between the two groups before and after supplementation.

Anthropometrics, body composition, and lipids and hepatic panel (Tables 3-4)

At the start of the supplementation, there were no significant differences between the two groups for body weight, body mass index (BMI), blood pressure, waist and hip circumference, and body composition (Table 3). There were still no significant differences in these parameters after supplementation with mango or placebo for 90 days. Additionally, when these variables were examined for differences due to time, there were no differences between the two groups when comparing the change from baseline in these parameters.

There was no significant difference between mango and placebo as well as change from baseline in lipid profile assessed by measuring total cholesterol, triglyceride, LDL, HDL, VLDL cholesterol, and LDL/HDL (Table 4). No significant differences were observed with treatment and time when measuring serum total protein, albumin, and globulin to monitor possible diabetic nephropathy (Table 4). Hepatic function was assessed by measuring aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase and there were no differences with treatment and time in these parameters (Table 4). Bilirubin, which is associated with a lower prevalence of oxidative stress-mediated diseases like T2D, significantly increased (P=0.002) for both treatment groups over the 90-day study (Table 4).

Diabetes parameters and inflammatory and oxidative stress markers (Table 5-7)

There was no significant difference in fasting blood glucose, glycated hemoglobin (HbA1C%), insulin, homeostatic model assessment - insulin resistance (HOMA-IR) with mango supplementation compared to placebo. There was also no difference between the two treatments when comparing change from baseline (Table 5).

Ghrelin, the hunger hormone, was significantly lower (P=0.013) in the mango group compared to the control but there was no significant difference with change from baseline (Table 5). There were no significant differences in C-peptide, gastric inhibitory peptide (GIP), glucagon-like peptide 1 (GLP-1), and visfatin (an indicator of β-cell function). Glucagon, an antagonist of insulin was also found to not be significant with treatment and time. Four markers of obesity and weight control; leptin, adiponectin, plasminogen activator inhibitor-1 (PAI-1) and resistin were measured and there were no significant differences with mango supplementation compared to placebo as well as no change with time (Table 5).

Interleukin (IL)-13, an anti-inflammatory protein, was significantly lower (P=0.028) in the mango group when compared to placebo, but there was no difference in change from baseline (Table 6). The pro-inflammatory protein, TNF-α, was significantly lower (P=0.040) in the mango

group when compared to the placebo, but similar to the IL-13 was not changed with time (Table 6). There was no significant difference in pro-inflammatory cytokines, IL-1β, IL-8, IL-12p70, interferon gamma (IFNγ), and monocyte chemoattractant protein-1 (MCP-1). The anti-inflammatory proteins, IL-6 and IL-10 displayed no significant differences. There were no significant differences when measuring IL-9, vascular endothelial growth factor (VEGF), fibroblast growth factor (FGF), and granulocyte colony-stimulating factor (GCSF), to assess cell growth (Table 6). Antioxidants were measured to assess oxidative stress and were found to be significantly lower (P=0.037) in the mango group when compared to the control group (Table 7). TBARS was also measured to assess lipid peroxidation and there were no significant differences.

CONCLUSION

Although we did not see a reduction in blood glucose parameters with twelve weeks of freeze-dried mango supplementation, our findings indicate that chronic consumption of mango by individuals with moderately elevated blood glucose does not cause negative changes in blood glucose, body weight, lipid parameters, and inflammatory markers associated with T2D. Our findings also indicate that mango may have protective effects by increasing bilirubin levels. Additional clinical trials with a higher dose used in this study, longer duration of supplementation and larger sample sizes still need to be conducted.

ADDENDUM (POST-PRANDIAL STUDY)

Since the findings of the proposed study was not too exciting and there were some more funds available, a pilot study was conducted to investigate the effects of freeze-dried mango on clinical parameters, inflammatory markers, and oxidative stress in healthy young adult males following a typical American breakfast meal (post-prandial state). The importance of the

postprandial state in the development of chronic diseases is increasingly being recognized.[12] Approximately sixteen hours a day are spent in the postprandial phase and changes that occur during this phase, particularly after consuming a high fat meal, can have a significant impact on the body and the development of chronic diseases, such as diabetes.

For this pilot study, twenty-five healthy adult males (18- 25 years old) were recruited from to participate in a crossover study design. Any healthy males within our specified age range that is willing to consume the breakfast meal and mango supplement were included in the study. Exclusion criteria included having taken (within the last month) or currently taking supplements, diagnosed with a medical condition, smoking, or consumption of alcohol and illicit drugs. Once the participants have been pre-screened, they came to the study site on a Saturday morning following an overnight fast. After providing consent, a baseline blood draw was obtained by a trained phlebotomist. After the first blood draw, they were given twenty minutes to consume a typical American breakfast meal (sausage and egg biscuit with a hash brown from McDonald's) with or without a mango shake (containing 50g freeze-dried mango powder, a cup of water, and a cup of ice blended together). The order whether they will receive the mango supplement or not was done in random. Additional blood draws were taken at 1, 2, and 4 hours after the meal was finished. After the first visit, participants were crossover to the other treatment following a 3-4-week washout period. Various measurements were conducted at both visits and the blood samples were analyzed for various parameters.

Table 8 shows the characteristics of the study participant for the post-prandial study. Laboratory and statistical analyses are still currently being conducted. One MS student is working on this project for her MS thesis. Preliminary results from this study were presented to the Oklahoma Academy of Nutrition and Dietetics Symposium in April 2016.

Table 1. Baseline characteristics

Parameter	Mango (n=26)	Placebo (n=24)	P value
Number of male (female) participants	10 (16)	7 (17)	
Age *(yrs*)	38.8 ± 14.1	44.0 ± 15.4	0.3712
Weight *(lbs)*	188.6± 9.1	196.5± 10.6	0.581
Height (*in*)	65.8 ± 3.4	66.0 ± 3.4	0.8804
BMI (*kg/m^2*)	30.8± 1.9	31.8± 1.6	0.670
Screening blood glucose (*mg/dL*)	103.4± 3.7	106.9± 8.2	0.1734

Values are mean ± standard error. Significance level set at *P* value <0.05. Body mass index (BMI); screening blood glucose was assessed by a home-testing glucometer (Onetouch, Shelton, CT).

Table 2. Effect of 90-days supplementation with mango or a placebo on dietary intake and physical activity levels of individuals with moderately elevated blood glucose

Parameter	Mango			Placebo			P value			P value
	Baseline (n=17)	Final (n=20)	Change§	Baseline (n=18)	Final (n=18)	Change§	Time	Treat-ment	Time X Treat-ment	change from baseline
Total Energy *(kcal)*	1808 ± 200	1796 ± 176	12 ± 218	1820 ± 129	1828 ± 198	-8 ± 283	0.906	0.957	0.590	0.441
Protein *(g)*	73 ± 6	68 ± 4	5 ± 6	69 ± 5	74 ± 5	-5 ± 9	0.828	0.968	0.167	0.096
Carbohydrate *(g)*	216 ± 27	225 ± 22	-9 ± 34	230 ± 17	242 ± 35	-12 ± 43	0.836	0.602	0.694	0.616
Sugar *(g)*	86 ± 12	82 ± 11	4 ± 15	84 ± 9	80 ± 13	4 ± 16	0.460	0.783	0.596	0.377
Fiber *(g)*	16 ± 2	17 ± 2	-1 ± 3	19 ± 2	18 ± 3	1± 4	0.866	0.468	0.885	0.858
Total Fat *(g)*	73 ± 9	68 ± 9	8 ± 9	70 ± 7	63 ± 7	7 ± 13	0.558	0.633	0.740	0.562
Cholesterol (*mg*)	224± 26	236± 28	-12± 34	227± 29	245±41	-18± 55	0.563	0.920	0.492	0.468
Vitamin C (*mg*)	54 ± 11	124± 26	-70± 10	74± 13	79± 13	-5± 35	0.171	0.650	0.094	**0.062**
Sodium (*mg*)	2725±346	2915±250	-190± 364	2948± 252	2929± 370	19± 510	0.897	0.983	0.752	0.662
Weekly physical activity (min)										
Light Activity	350 ± 77	223 ± 35	127.0± 84	301± 75	395± 116	-94 ± 119	0.834	0.441	0.169	0.252
Moderate activity	234 ± 99	145 ± 30	89± 114	184± 50	159± 33	25 ± 56	0.346	0.764	0.600	0.587
Strenuous activity	106 ± 34	111± 31	-5 ± 37	85± 32	135 ± 40	-50 ± 40	0.423	0.968	0.512	0.394

Values are mean ± standard error. Significance level set at *P* value <0.05. § Change means baseline minus final values.

Table 3. Effects of 90-days supplementation with mango or a placebo on body weight, blood pressure, waist and hip circumference, and body composition of individuals with moderately elevated blood glucose

Parameter	**Mango**			**Placebo**			**P value**			**P value**
	Baseline (n=26)	Final (n=26)	Change§	Baseline (n=24)	Final (n=24)	Change§	Time	Treat-ment	Time X Treat-ment	change from baseline
Weight *(lbs)*	186.7± 1.8	193.3± 7.9	-6.6± 4.4	189.3± 7.8	190.9± 8.5	-1.6± 6.05	0.587	0.975	0.745	0.152
BMI *(kg/m²)*	31.0± 1.3	31.5± 1.4	-0.5± 0.1	30.8± 1.3	31.3± 1.4	-0.5± 1.0	0.730	0.869	0.993	0.243
Blood pressure (mm Hg)										
Systolic	128 ± 3	130 ± 3	-2± 4	128 ± 3	131 ± 3	-3± 2	0.422	0.914	0.711	0.628
Diastolic	80 ± 2	80 ± 2	0.7± 2	81 ± 2	80 ± 2	1± 1	0.629	0.788	0.869	0.854
Circumference (in)										
Waist	39.5± 1.2	40.3± 1.2	-0.8± 2.7	40.0± 1.4	39.7± 1.4	0.3± 4.1	0.860	0.962	0.685	0.697
Hip	43.5± 1.2	44.2± 1.1	-0.7± 3.0	44.1± 1.4	44.5± 1.4	-0.4± 4.0	0.651	0.752	0.894	0.681
Body Composition										
BMC *(g)*	2448± 71	2588± 153	-100± 123	2398± 68	2407± 66	-9± 9.6	0.445	0.241	0.506	0.346
BMD *(g/cm²)*	1.18± 0.02	1.18± 0.02	-0.0± 0.0	1.16± 0.02	1.16± 0.02	-0.0± 0.0	0.904	0.462	0.953	0.446
Fat Mass *(kg)*	30.8± 2.5	30.3± 2.3	0.5± 1.4	31.9± 2.5	32.0± 2.5	0.1± 1.4	0.919	0.584	0.894	0.716
% Fat	35.0± 1.9	34.4± 1.7	0.6± 0.3	36.1± 1.9	36.1± 1.9	0.0± 0.3	0.856	0.438	0.863	0.977

Values are mean ± standard error. Significance level set at *P* value <0.05. BMI- body mass index, BMC-bone mineral content, BMD- bone mineral density. § Change means baseline minus final values.

Table 4. Effects of 90-days supplementation with mango or a placebo on lipids and liver panel of individuals with moderately elevated blood glucose

Parameters	Mango			Placebo			P value			P value
	Baseline (n=26)	Final (n=26)	Change§	Baseline (n=24)	Final (n=24)	Change§	Time	Treatment	Time X Treat-ment	change from baseline
Lipid Panel										
Total Cholesterol *(mg/dL)*	177± 6	180± 6	-3± 4	181 ± 6	180 ± 6	1 ± 4	0.928	0.734	0.773	0.491
Triglycerides *(mg/dL)*	124± 16	133 ± 15	-9± 11	128± 16	123± 12	5 ± 6	0.893	0.823	0.664	0.509
LDL Cholesterol *(mg/dL)*	105± 5	106 ± 5	-1± 3	106 ± 5	105 ± 5	1 ± 3	0.988	0.933	0.887	0.622
HDL Cholesterol *(mg/dL)*	48 ± 2	47 ± 2	1 ± 7	50 ± 2	50 ± 2	0 ± 1	0.809	0.276	0.710	0.421
VLDL Cholesterol *(mg/dL)*	25 ± 3	27 ± 3	-2± 2	26± 3	24 ± 2	2 ± 1	0.887	0.829	0.645	0.468
LDL/HDL *(mg/dL)*	2.3± 0.2	2.4± 0.2	-0.1± 0.1	2.2± 0.2	2.2± 0.2	0.1± 0.1	0.945	0.494	0.786	0.243
Hepatic Panel										
Total protein (*gm/dL*)	7.1± 0.1	7.1± 0.1	-0.0± 0.1	7.1± 0.1	7.1± 0.1	0.0± 0.1	0.818	0.810	0.695	0.622
Albumin (*gm/dL*)	4.2± 0.1	4.2± 0.1	-0.0± 0.1	4.2± 0.0	4.2± 0.1	0.0± 0.1	0.994	0.935	0.929	0.960
Globulin (*gm/dL*)	2.9± 0.1	3.0± 0.1	-0.1± 0.1	3.0± 0.1	2.9± 0.1	0.1± 0.1	0.840	0.725	0.555	0.423
AST (*U/L*)	27± 3	26 ± 2	1± 2.7	28± 3	26 ± 2	2 ± 3	0.602	0.979	0.751	0.678
ALT(*U/L*)	40± 2	39 ± 2	0.7± 2.6	41± 6	36 ± 2	5 ± 6	0.509	0.797	0.548	0.442
Alkaline Phosphatase (*U/L*)	74± 3	77± 3	-3.2± 2.5	76 ± 4	79± 4	-3 ± 0.1	0.462	0.505	0.929	0.926
Bilirubin (*gm/dL*)	0.2± 0.0	0.3± 0.1	-0.1± 0.0	0.2± 0.0	0.3± 0.0	-0.1± 0.1	**0.002**	0.811	0.159	0.122

Values are mean ± standard error. Significance level set at *P* value <0.05. low-density lipoprotein (LDL), high-density lipoprotein (HDL), very-low-density lipoprotein (VLDL), aspartate aminotransferase (AST), alanine transaminase (ALT). § Change means baseline minus final values.

Table 5. Effects of 90-days supplementation with mango or a placebo on glucose parameters of individuals with moderately elevated blood glucose

Parameters	**Mango**			**Placebo**			**P value**			**P value**
	Baseline (n=26)	Final (n=26)	Change[§]	Baseline (n=24)	Final (n=24)	Change[§]	Time	Treat-ment	Time X Treat-ment	change from baseline
Glucose *(mg/dL)*	97± 2	96± 2	1± 1.5	98± 2	98± 2	0.1± 1.9	0.595	0.512	0.638	0.435
HbA1C %	5.4± 0.1	5.4± 0.1	-0.0± 0.1	5.4± 0.1	5.4± 0.1	-0.3± 0.2	0.389	0.949	0.901	0.308
Insulin *(mg/mL)*	6.4± 0.7	6.6± 0.8	-0.3± 0.4	6.1± 0.8	6.2± 0.9	-0.1± 0.4	0.907	0.698	0.999	0.771
HOMA-IR*(mg/mL)*	1.6± 0.2	1.6± 0.2	-0.0± 0.1	1.5± 0.2	1.6± 0.3	-0.0± 0.1	0.965	0.8825	0.9145	0.988
C-Peptide *(pg/mL)*	1564± 142	1521± 146	44± 40	1468± 142	1565± 159	-96+ 64	0.858	0.862	0.636	0.070
Ghrelin *(pg/mL)*	1273±114	1285±120	-12± 55	1629±164	1666±177	-38± 76	0.864	**0.013**	0.930	0.784
Leptin *(mg/dL)*	16.0± 3.0	19.8± 3.0	-3.0± 1.9	18.1± 3.6	20.0± 4.9	-1.9± 2.7	0.954	0.740	0.952	0.741
Adiponectin (*µg/mL*)	9.2± 1.2	9.0± 1.1	0.2± 0.6	8.8± 1.4	9.0± 1.5	-0.2± 0.5	0.991	0.841	0.883	0.453
GIP *(pg/mL)*	565±68	552±64	13± 75	490±38	633±86	-143± 67	0.334	0.243	0.965	0.129
GLP-1 *(pg/mL)*	324±12	321±11	3± 9	302±8	306±12	-4± 10	0.975	0.090	0.733	0.587
Glucagon *(pg/mL)*	316±23	309±20	8± 9	332±24	345±27	-13± 14	0.910	0.278	0.669	0.226
PAI-1 *(pg/mL)*	6351±570	6498±571	-148±487	6265±438	6211±527	54± 539	0.930	0.727	0.850	0.783
Resistin *(pg/mL)*	3965±255	4097±269	-132±125	4180±290	4516±340	-337± 147	0.420	0.276	0.724	0.293
Visfatin *(pg/mL)*	1148 ±157	960 ±135	188± 134	1145±142	890±141	256± 234	0.128	0.801	0.816	0.801

Values are mean ± standard error. Significance level set at *P* value <0.05. glycated hemoglobin (HbA1C %), homeostatic model assessment-insulin resistance (HOMA-IR), connecting peptide (C-Peptide), gastric inhibitory peptide (GIP), glucagon-like peptide 1 (GLP-1), plasminogen activator inhibitor-1 (PAI-1). [§] Change means baseline minus final values.

Table 6. Effect of 90-days supplementation with mango or a placebo on selected plasma cytokines of individuals with moderately elevated blood glucose

Parameter *(pg/ml)*	**Mango**			**Placebo**			**P value**			**P value**
	Baseline (n=21)	Final (n=21)	Change§	Baseline (n=20)	Final (n=20)	Change§	Time	Treat-ment	Time X Treat-ment	Change from baseline
IL-1β	2.8± 0.8	2.4± 0.6	0.4± 0.4	2.8± 0.8	3.1 ± 0.8	-0.3± 0.4	0.985	0.634	0.650	0.242
IL-6	4.0±1.2	3.2±0.9	0.8± 0.8	5.0±1.4	5.2±2.8	-0.2± 0.8	0.801	0.275	0.698	0.352
IL-8	11.6±2.4	11.0±1.7	0.5± 1.6	15.7±3.6	13.9±2.9	1.8± 1.8	0.660	0.196	0.813	0.600
IL-9	24.5±4.2	23.8±3.1	0.7± 1.1	35.2±7.1	31.3±5.9	3.9± 2.4	0.659	0.086	0.760	0.390
IL-10	12.9±3.1	11.0±2.1	1.8± 2.0	20.0±6.0	16.9±3.9	3.1± 2.7	0.542	0.106	0.879	0.716
IL-12p70	32±10	20±4	11± 7	52±23	39±13	13± 11	0.401	0.173	0.957	0.903
IL-13	10.9±1.7	10.2±1.8	0.7± 5.2	21.4±6.3	16.4±6.5	4.9± 3.3	0.451	**0.028**	0.578	0.228
IFNγ	103±25	118±21	-15± 19	136±27	140±25	-4± 19	0.686	0.268	0.821	0.685
MCP-1	3.9±1.9	4.0±1.5	-0.1± 1.1	5.7±3.7	6.5±3.1	-0.8± 2.0	0.870	0.421	0.898	0.764
TNF-α	18.9±4.8	22.6±4.9	-3.7± 5.4	42.9±13.0	35.6±10.4	7.4± 4.4	0.836	**0.040**	0.535	0.124
VEGF	14.1±4.5	10.3±3.0	3.7± 2.4	26.6±11.7	19.8±6.8	6.8± 5.6	0.463	0.130	0.829	0.607
Basic FGF	48±10	40±7	8± 6	59±16	57±11	3± 6.	0.658	0.251	0.812	0.516
GCSF	72±12	69±8	3± 8	107±28	95±15	12± 15	0.663	0.078	0.792	0.599

Values are mean ± standard error. Significance level set at *P* value <0.05. interleukin-1 beta (IL-1β), interleukin-6(IL-6), interleukin-8 (IL-8), interleukin- 9 (IL-9), interleukin-10 (IL-10), interleukin- 12p70(IL-12p70), interleukin-13 (IL-13), interferon gamma (IFNγ), monocyte chemoattractant protein-1 (MCP-1), tumor necrosis factor-alpha (TNF-α), vascular endothelial growth factor (VEGF), fibroblast growth factor (FGF), granulocyte colony-stimulating factor (GCSF). § Change means baseline minus final values.

Table 7. Effect of 90-days supplementation with mango or a placebo on selected plasma oxidative markers of individuals with moderately elevated blood glucose

Parameter	**Mango**			**Placebo**			**P value**			**P value**
	Baseline (n=21)	Final (n=21)	Change§	Baseline (n=20)	Final (n=20)	Change§	Time	Treatment	Time X Treatment	Change from baseline
TBARS (µM)*	29± 6	38 ± 20	-9± 21	40 ± 13	27 ± 4	13± 11	0.890	0.992	0.366	0.362
Anti-oxidants (mM)	3.0± 0.5	2.7± 0.5	0.3± 0.3	3.7± 0.6	4.2± 0.6	-0.5± 0.4	0.845	**0.037**	0.405	0.104

Values are mean ± standard error. Significance level set at *P* value <0.05. Thiobarbituric acid reactive substances (TBARS). § Change means baseline minus final values.

Table 8. Characteristics of the study participants (post-prandial study)

Parameter	Mango	Placebo	P value
Weight *(lbs)*	175 ± 6	173 ± 7	**0.004**
Height (*in*)	70.7 ± 0.6	70.6 ± 0.6	0.258
BMI (*kg/m^2*)	24.6± 0.9	24.3± 0.9	**0.046**
Waist circumference *(in)*	34.6± 0.9	34.4± 0.9	0.407
Hip circumference *(in)*	37.2± 0.9	37.0± 0.7	0.470
Blood pressure (mm Hg)			
Systolic	123± 2	121± 2	0.258
Diastolic	70± 2	70± 2	0.681

Values are mean ± standard error; n=25; significance level set at *P* value <0.05.

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